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MODEL STUDY OF COOL WATER DISCHARGE FROM PROPOSED LNG FACILITY --ETC(U)

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**MODEL STUDY OF COOL WATER DISCHARGE
FROM PROPOSED LNG FACILITY
LOS ANGELES HARBOR, CALIFORNIA**

by

10 William H. McAnally, Jr.

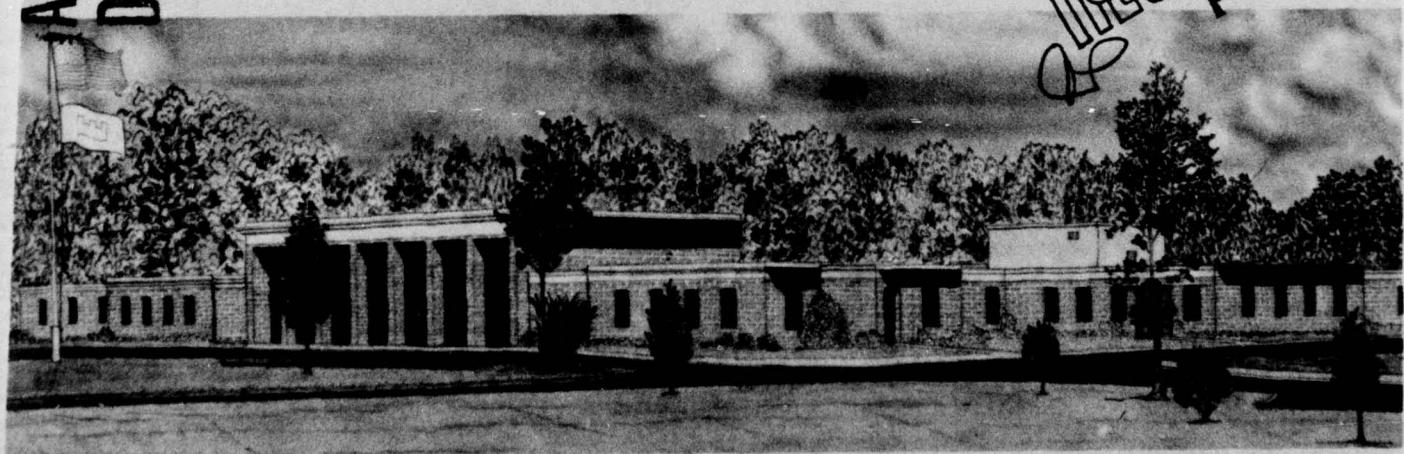
Hydraulics Laboratory
U. S. Army Engineer Waterways Experiment Station
P. O. Box 631, Vicksburg, Miss. 39180

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) Physical hydraulic model dye tests were conducted to define near-field dilution of a cool-water discharge from a proposed LNG facility in Los Angeles Harbor, California, and to describe the far-field behavior of the resulting plume.		

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PREFACE

The study described herein was conducted at the U. S. Army Engineer Waterways Experiment Station (WES) under an agreement with the Board of Harbor Commissioners, City of Los Angeles, California.

Personnel of the Hydraulics Laboratory of WES performed this study during the period December 1975 through May 1977 under the direction of Mr. H. B. Simmons, Chief of the Hydraulics Laboratory; Mr. F. A. Herrmann, Jr., Assistant Chief of the Hydraulics Laboratory; Mr. R. A. Sager, Chief of the Estuaries Division; Dr. R. W. Whalin, Chief of the Wave Dynamics Division; and Mr. G. M. Fisackerly, Chief of the Harbor Entrance Branch. Mr. W. H. McAnally, Jr., was Project Engineer, and Mr. J. T. Hilbun was the Project Senior Engineering Technician.

This report consists of two Memoranda for Record written by Mr. McAnally to convey preliminary model test results to the sponsors.

Messrs. W. L. Brown of Southern California Gas Company; L. L. Whiteneck, L. Anderson, and V. Hall of the Port of Los Angeles; and C. S. Todd of the City of Los Angeles participated in the planning of the tests described herein. Mr. R. A. Busch of Fluor Ocean Services provided preliminary designs of the LNG unloading platform. The co-operation and contributions of these individuals are gratefully acknowledged.

Directors of WES during the course of this study and the preparation and publication of this report were COL G. H. Hilt, CE, and COL John L. Cannon, CE. Technical Director was Mr. F. R. Brown.

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IN REPLY REFER TO: WESHE

1 June 1977

MEMORANDUM FOR RECORD

SUBJECT: Preliminary Data from Model Study of LNG Facility Cool-Water Discharge into Slip 302, Los Angeles Harbor

1. This memorandum conveys preliminary data from model tests of the LNG facility cool-water discharge system proposed for Slip 302, Los Angeles Harbor, California. Tests described herein were performed at the Waterways Experiment Station (WES) from November 1975 through February 1976 and November 1976 through May 1977, by agreement between the Port of Los Angeles and WES. Preliminary data from the November 1975 through February 1976 tests were sent to the Port of Los Angeles in February 1976 (Reference 1).

2. The purpose of the recent model tests was to compare near-field dilution of the cool-water plume when discharged through a four-pipe system with that resulting from a single pipe. These data are presented in preliminary form so that they can be available more quickly than possible with a formal report.

Model

3. These tests were conducted in an undistorted, 1:50-scale model of Slip 302, Los Angeles Harbor (see Figure 1). The model is described in Reference 1.

4. The model discharge pipes were also constructed to the 1:50-size scale. The four-pipe system consisted of 72-inch-diameter pipes (see Figure 2) passing through the north end of the slip with a center-line elevation of -12 feet mean lower low water (mllw) and spaced in a line symmetrically about the slip bottom width center line on 75-foot centers. The axis of each pipe was parallel to the slip center line. The single pipe (see Figure 3) tested had a 96-inch diameter and passed through the slip's north wall on the center line at an elevation of -12 feet mllw. The pipe axis was perpendicular to the north wall of the slip.

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SUBJECT: Preliminary Data from Model Study of LNG Facility Cool-Water Discharge into Slip 302, Los Angeles Harbor

Description of Tests

5. Two discharge plans were tested for both pipe systems--62,100-gallons per minute (gpm) commingled LNG facility cool-water and Terminal Island Treatment Plant effluent at a combined salinity of 27 parts per thousand (ppt) and temperature of 56°F; and 87,000-gpm LNG facility discharge alone at 34 ppt and 56°F. Ambient water conditions were taken to be 34 ppt and 60°F. In the model, density differences between effluent and receiving water were achieved by varying their relative salinities such that the densimetric Froude number of the effluent was equal in model and prototype.

6. The water surface elevation in the model was held constant during the tests at the mean tide level, +2.8 feet mllw.

7. A conservative fluorescent dye was added to the model effluent so that it could be traced. Water samples were withdrawn from 12 stations (see Figure 2) at 70-minute (prototype) intervals for an equivalent 14.1 prototype hours. Surface or bottom samples were taken at every station depending on whether a sinking plume or rising plume was being tested. Both surface and bottom samples were taken at Stations 2C, 2E, 3C, and 3E. Samples were taken at eight depths at Station 2D to define the plume interface. The water samples were fluorometrically analyzed to determine dye content and thus degree of plume dilution at each sample point.

Results

8. Plots of relative dye concentration versus time for the four-pipe and one-pipe discharge systems are shown in the attached plates. Four-pipe results have been plotted as Base tests and the single-pipe results are shown as Plan 1. The relative concentrations have been normalized by the source concentration in each test so that the results can be directly compared. Concentration time histories for the 87,000-gpm discharge show that plume concentrations were higher for the single pipe than for the four-pipe system. With four pipes, the plume concentration reached a peak 6 hours after starting the discharge whereas the peak was not obtained until about 11 hours for the single pipe. The 62,100-gpm discharge plume concentrations also are higher for the single pipe except at Station 2C where the terminal concentrations are essentially equal for both systems.

9. Table 1 shows the 87,000-gpm LNG facility discharge terminal concentrations for the one- and four-pipe systems. For both Ranges 2 and 3, the average plume concentration is higher for the one-pipe (36 percent) than for the four-pipe system (20 percent). In addition, Range 3 shows a nonuniform concentration distribution with higher concentrations on the east side of the slip, probably due to the angle of the discharge pipe.

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SUBJECT: Preliminary Data from Model Study of LNG Facility Cool-Water Discharge into Slip 302, Los Angeles Harbor

10. Table 2 shows the 62,100-gpm commingled discharge terminal concentrations. Again, the average plume concentration is higher for the one-pipe (42 percent and 46 percent) than for the four-pipe system (34 percent and 37 percent).

11. Figure 4 shows dye concentration profiles for the 87,000-gpm discharge. Higher plume concentrations for the single pipe are illustrated, and it is seen that the plume interface is more sharply defined than for the four-pipe system.

12. Concentration profiles for the 62,100-gpm discharge are illustrated by Figure 5. Although the single-pipe peak concentration is higher, it appears that the plume is much thinner than for the four-pipe system. With the single pipe, concentrations at the 5 percent depth fluctuated between 5 percent and 35 percent of the source concentration, indicating that the plume interface was very close to that depth.

13. In summary, the single-pipe system caused a reduction in plume dilution in comparison to the four-pipe system for both discharges tested. Concomitant changes in plume thickness occurred, but the changes were not large.

William H. McAnally

19 Incl

- 1. Reference
- 2. Tables 1 and 2
- 3-7. Figures 1-5
- 8-19. Plates (12, unnumbered)

WILLIAM H. MCANALLY, JR.
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Harbor Entrance Branch

Reference

1. USAE Waterways Experiment Station, Memorandum for Record, subject:
Preliminary Data from Model Study of LNG Facility Cool-Water
Discharge into Los Angeles Harbor, 20 February 1976.

Tool 1

PRELIMINARY DATA

TABLE 1

TERMINAL BOTTOM CONCENTRATIONS
AS PERCENT OF SOURCE
87,000-gpm LNG Discharge

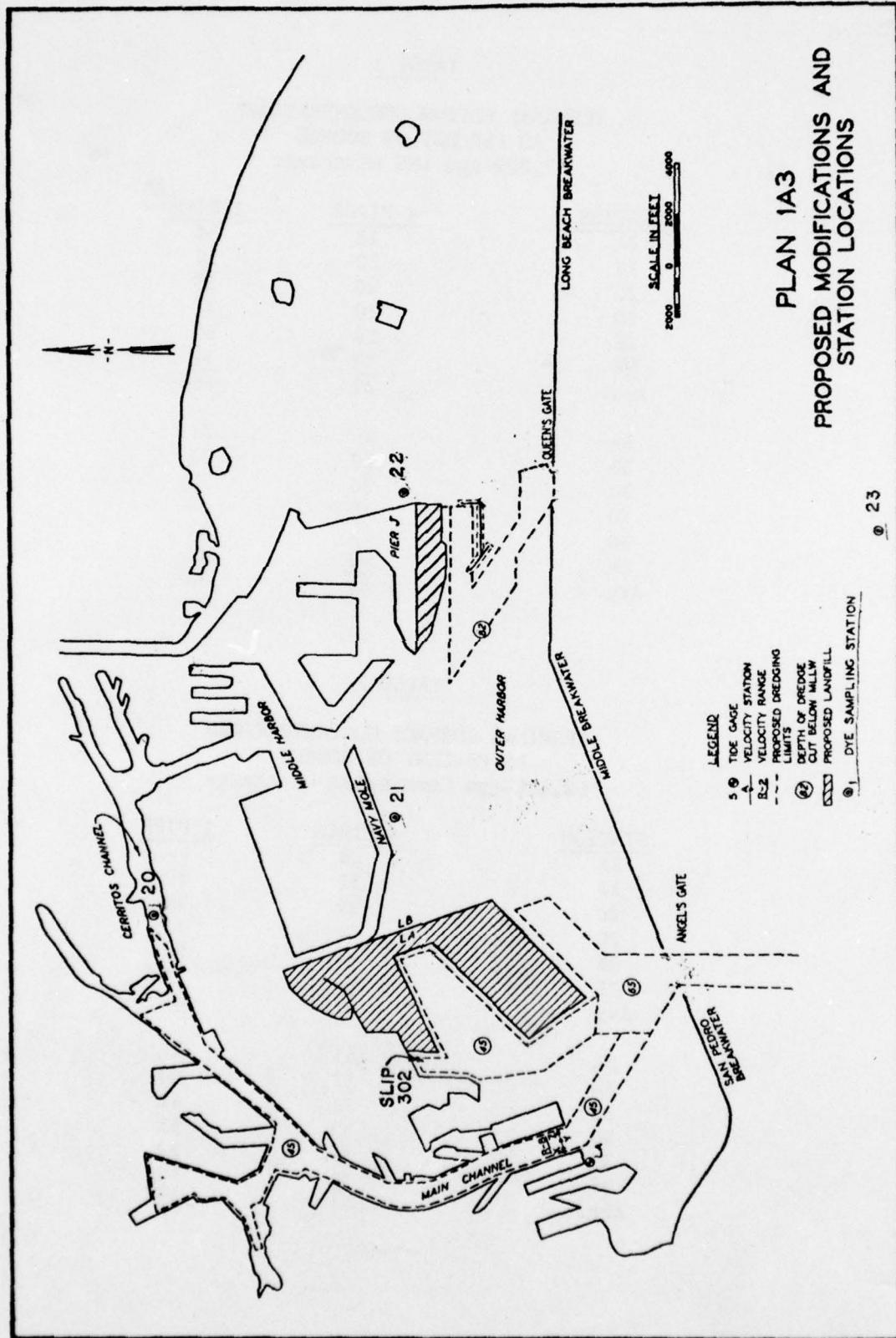
<u>STATION</u>	<u>4 PIPES</u>	<u>1 PIPE</u>
2A	18	34
2B	20	37
2C	20	39
2D	20	37
2E	19	37
2F	20	31
Avg.	20	36
3A	19	31
3B	19	33
3C	20	36
3D	19	38
3E	21	37
3F	20	42
Avg.	20	36

TABLE 2

TERMINAL SURFACE CONCENTRATIONS
AS PERCENT OF SOURCE
62,100-gpm Commingled Discharge

<u>STATION</u>	<u>4 PIPES</u>	<u>1 PIPE</u>
2A	28	--
2B	31	50
2C	39	38
2D	39	48
2E	42	54
2F	42	38
Avg.	37	46
3A	31	42
3B	37	40
3C	32	42
3D	33	41
3E	34	39
3F	34	50
Avg.	34	42

FIGURE I



Incl 3-7

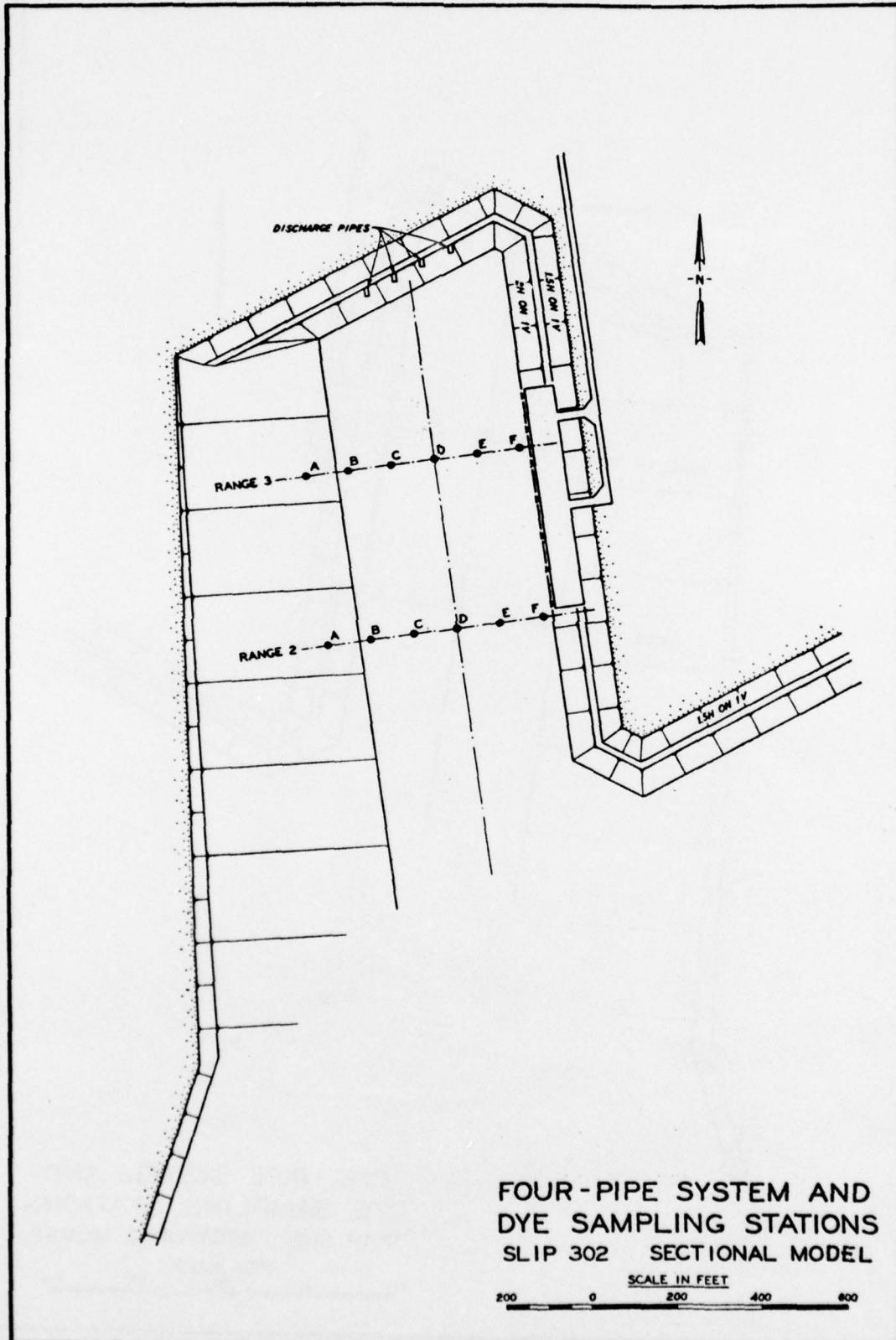


FIGURE 2

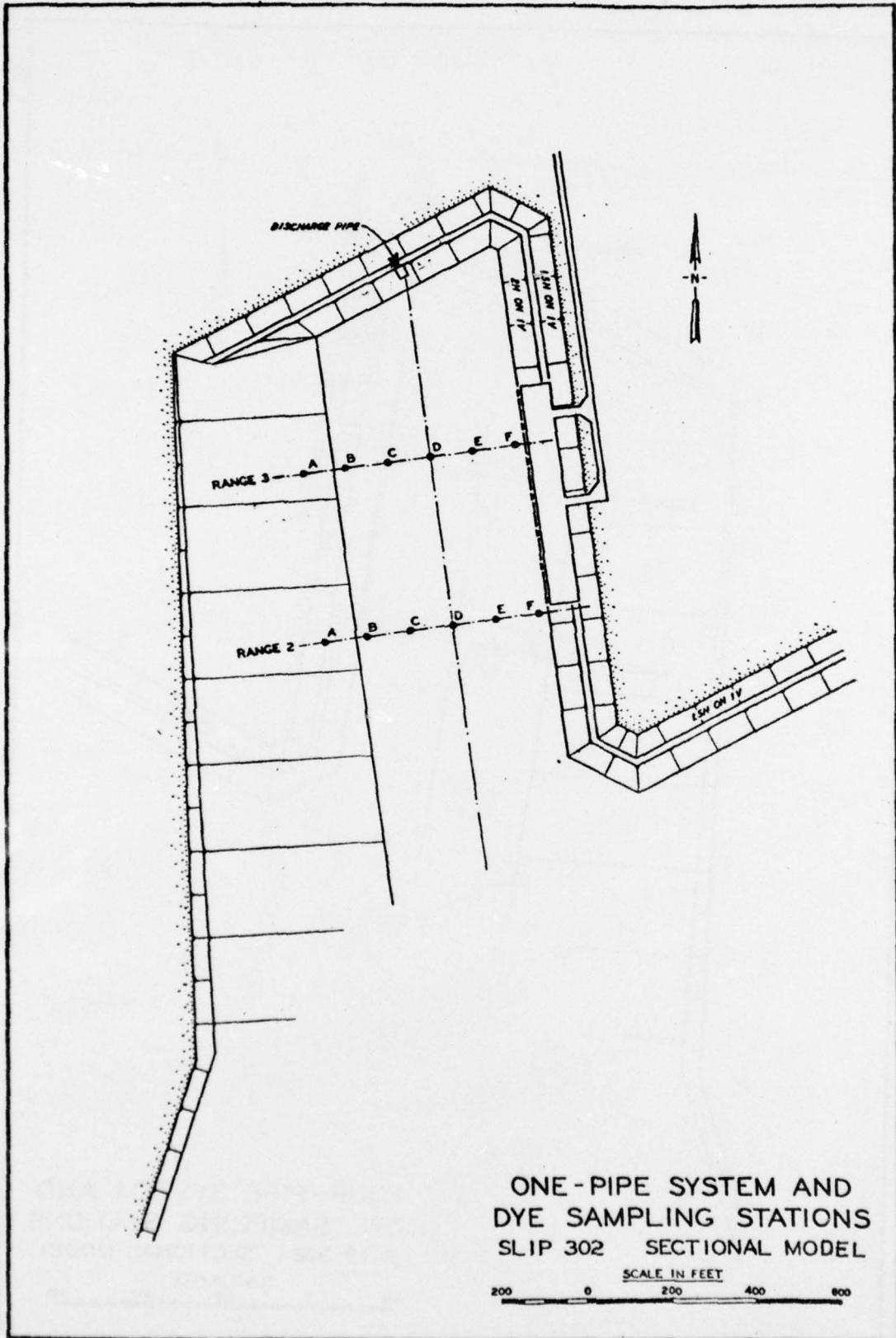
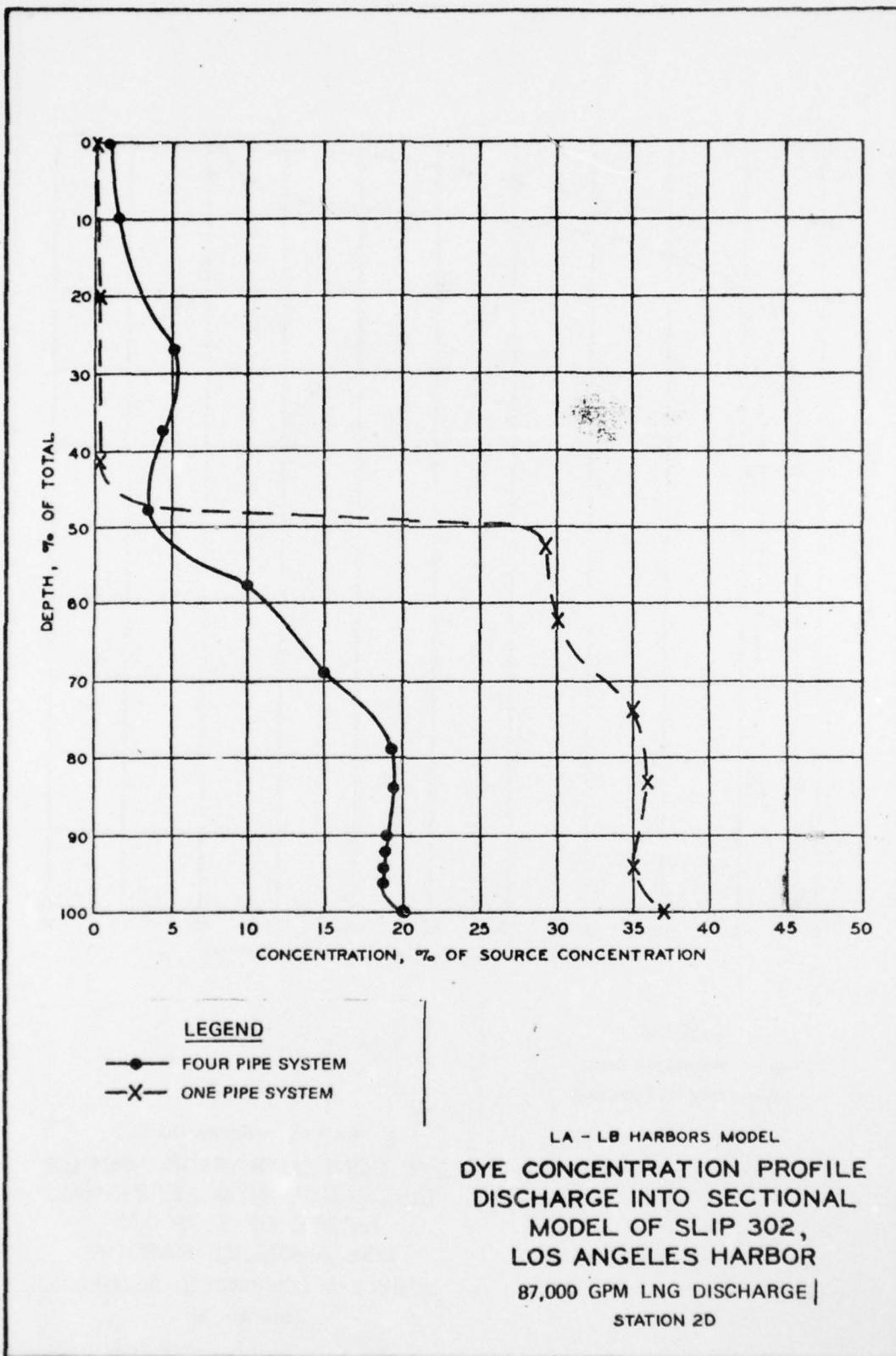
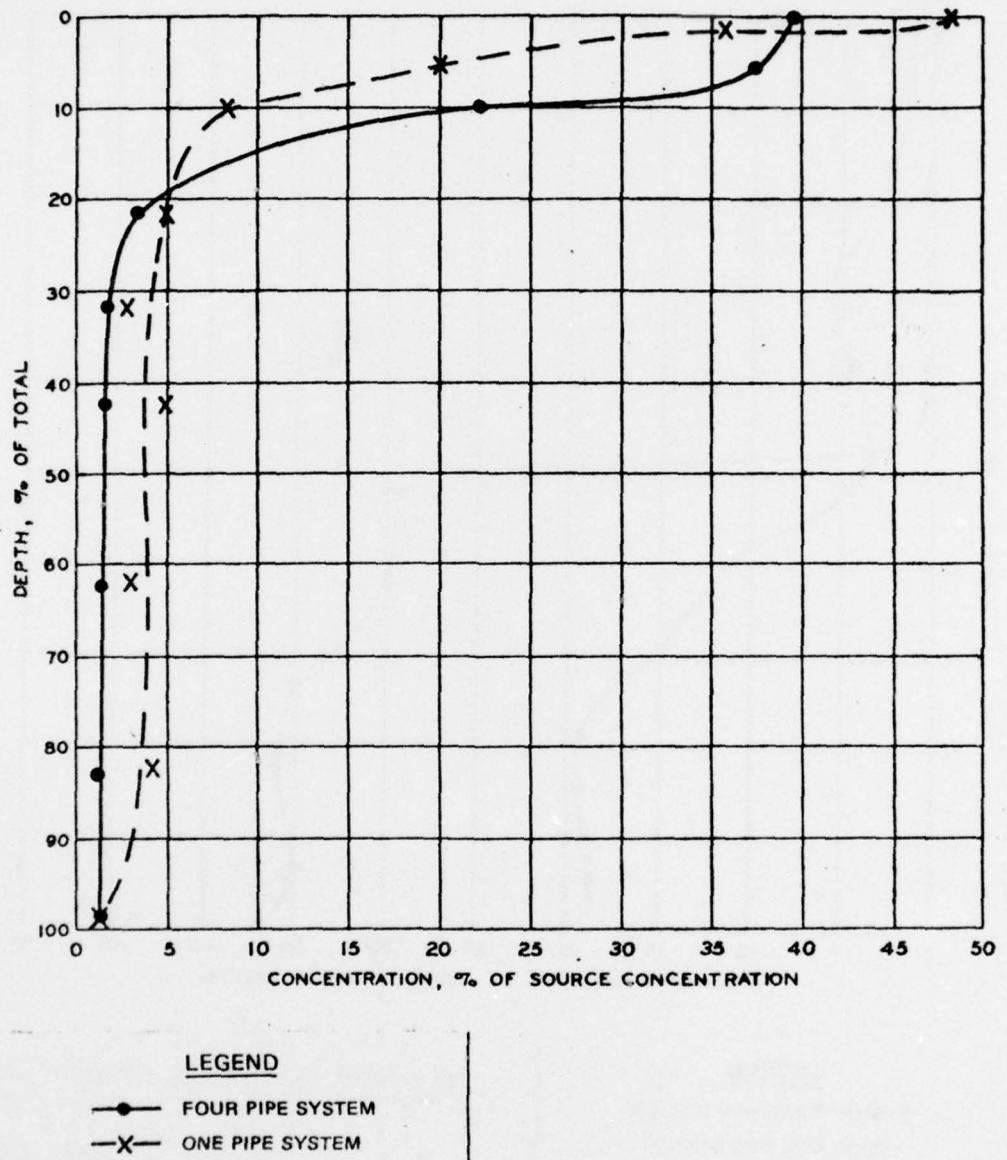


FIGURE 3



PRELIMINARY DATA

FIGURE 4

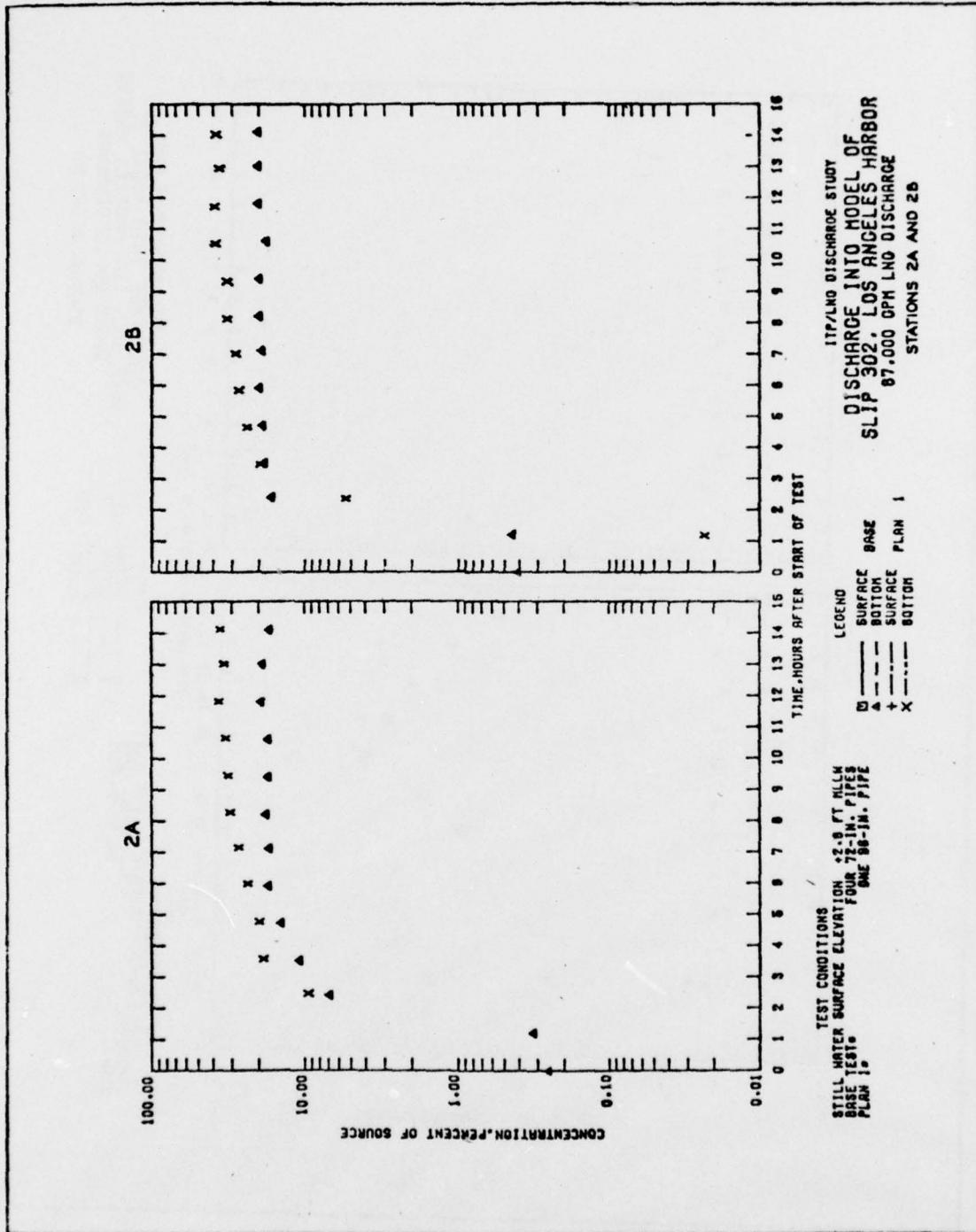


LA - LB HARBORS MODEL
DYE CONCENTRATION PROFILE
 DISCHARGE INTO SECTIONAL
 MODEL OF SLIP 302,
 LOS ANGELES HARBOR
 62,000 GPM COMMINGLED DISCHARGE |
 STATION 2D

PRELIMINARY DATA

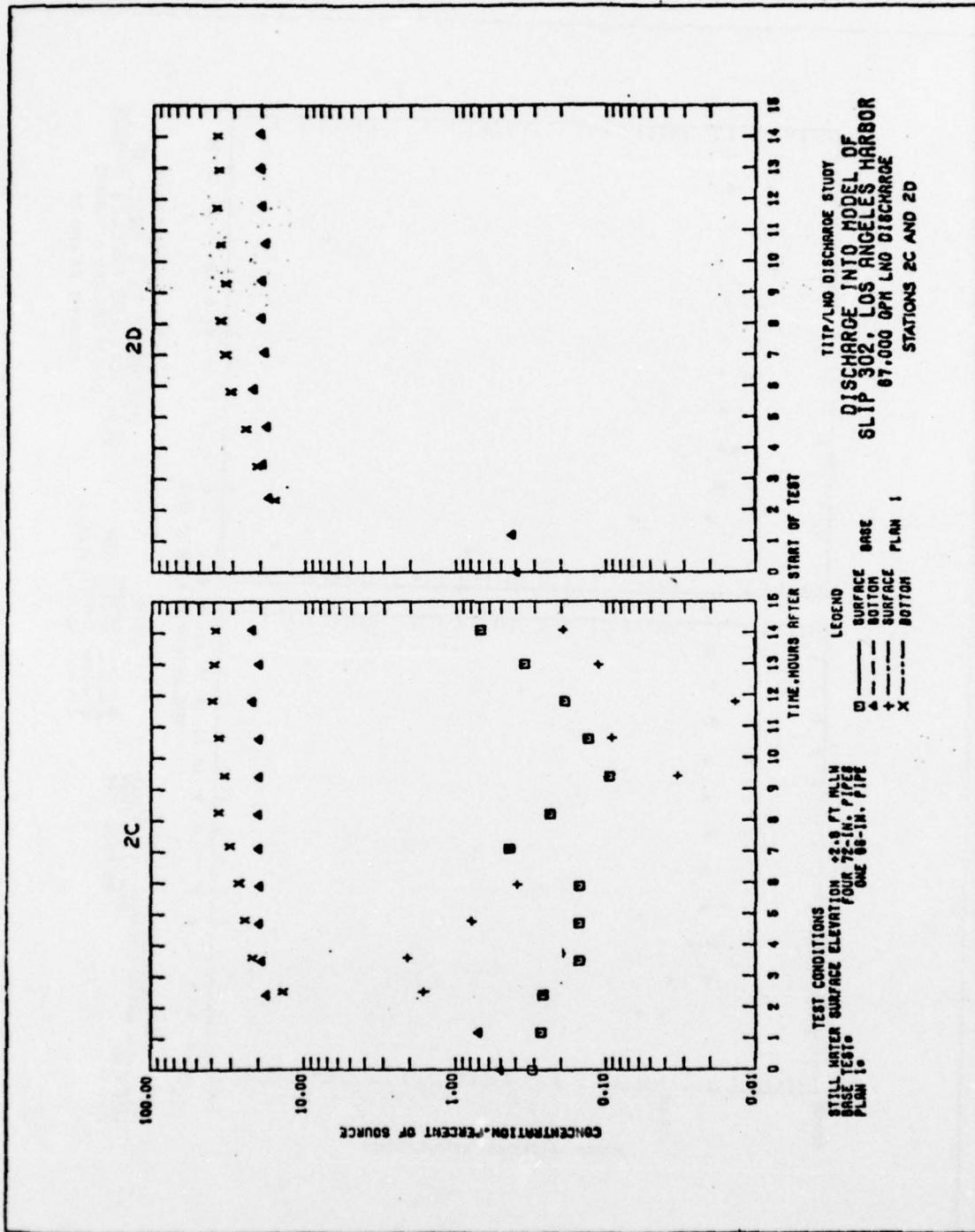
FIGURE 5

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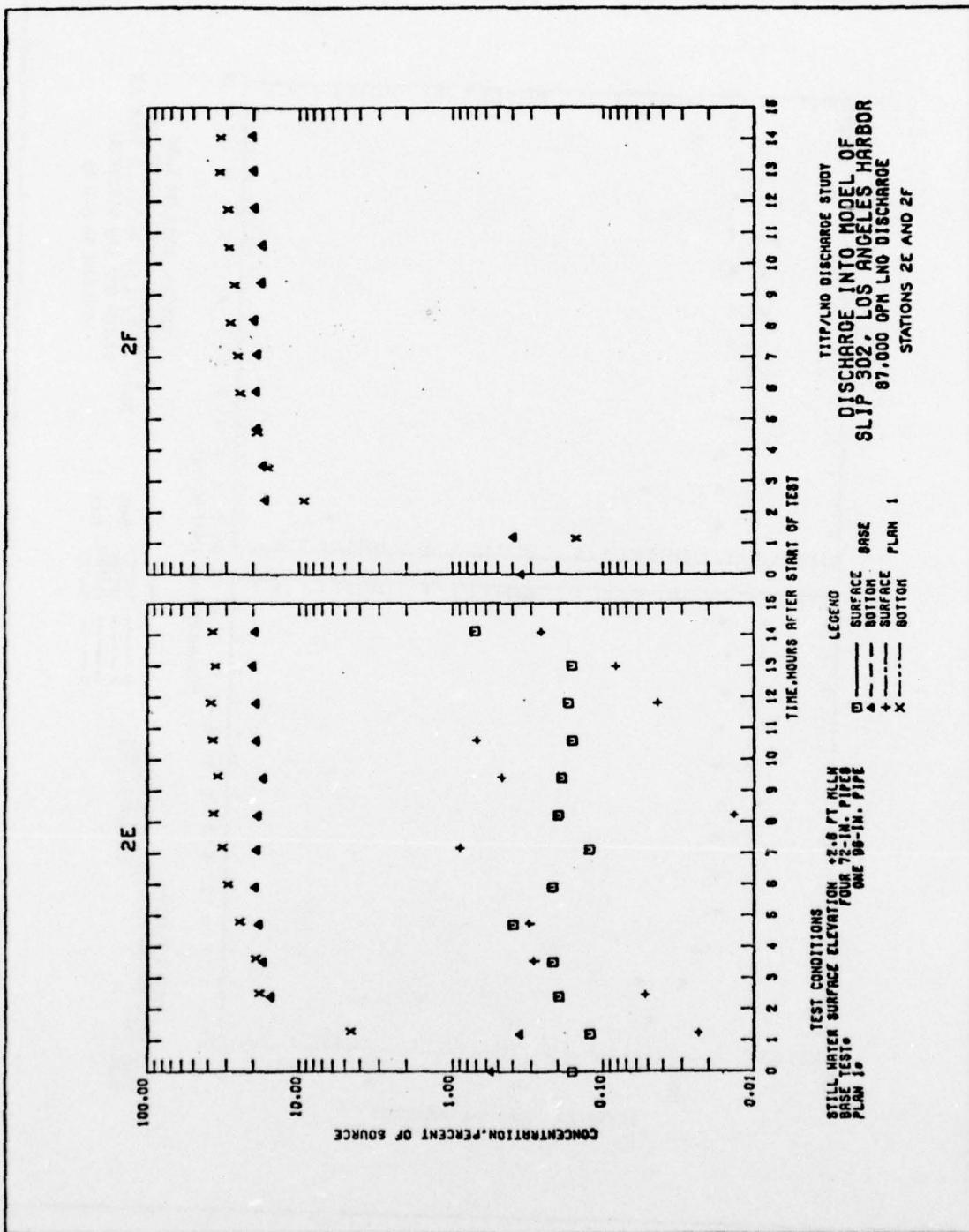


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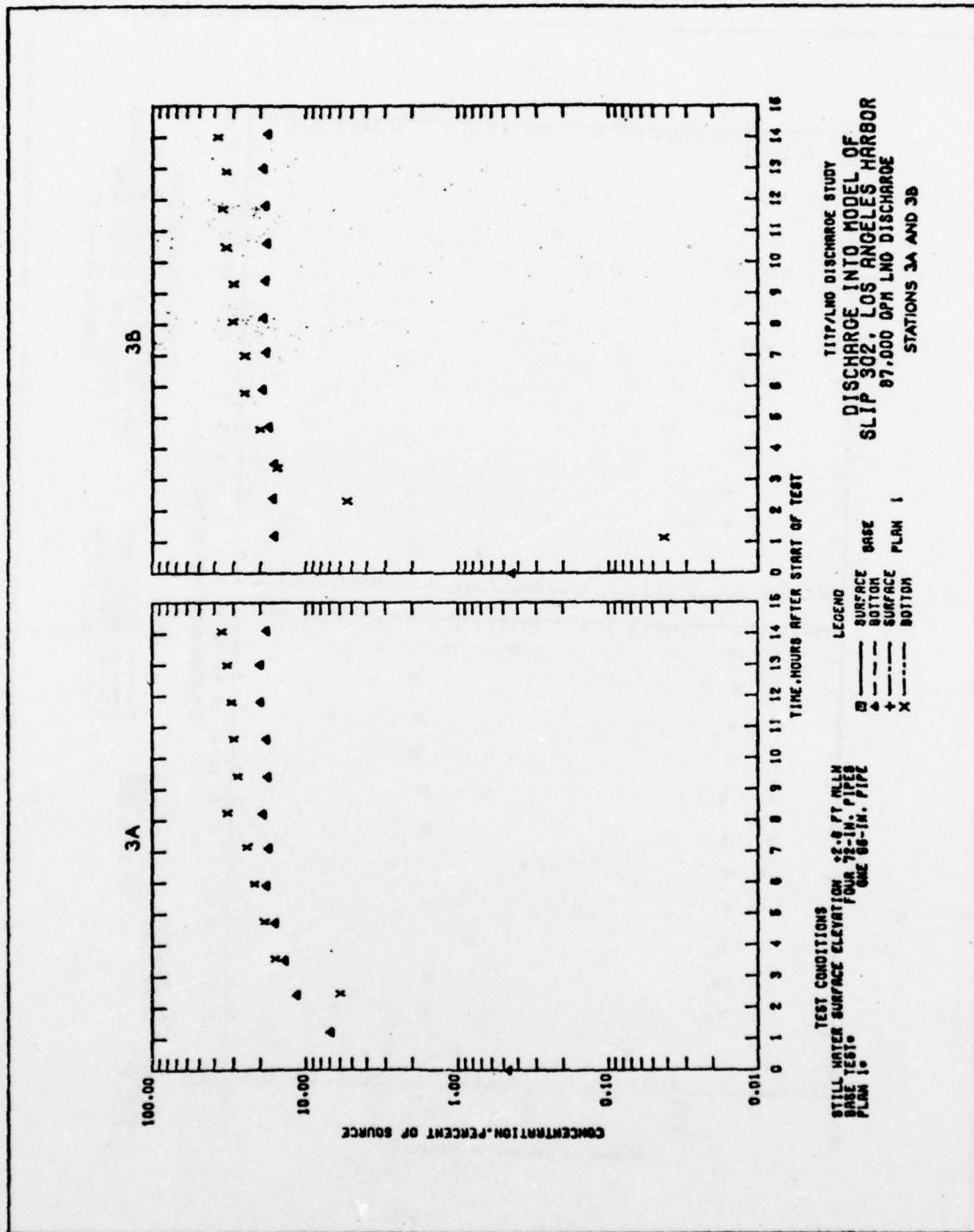
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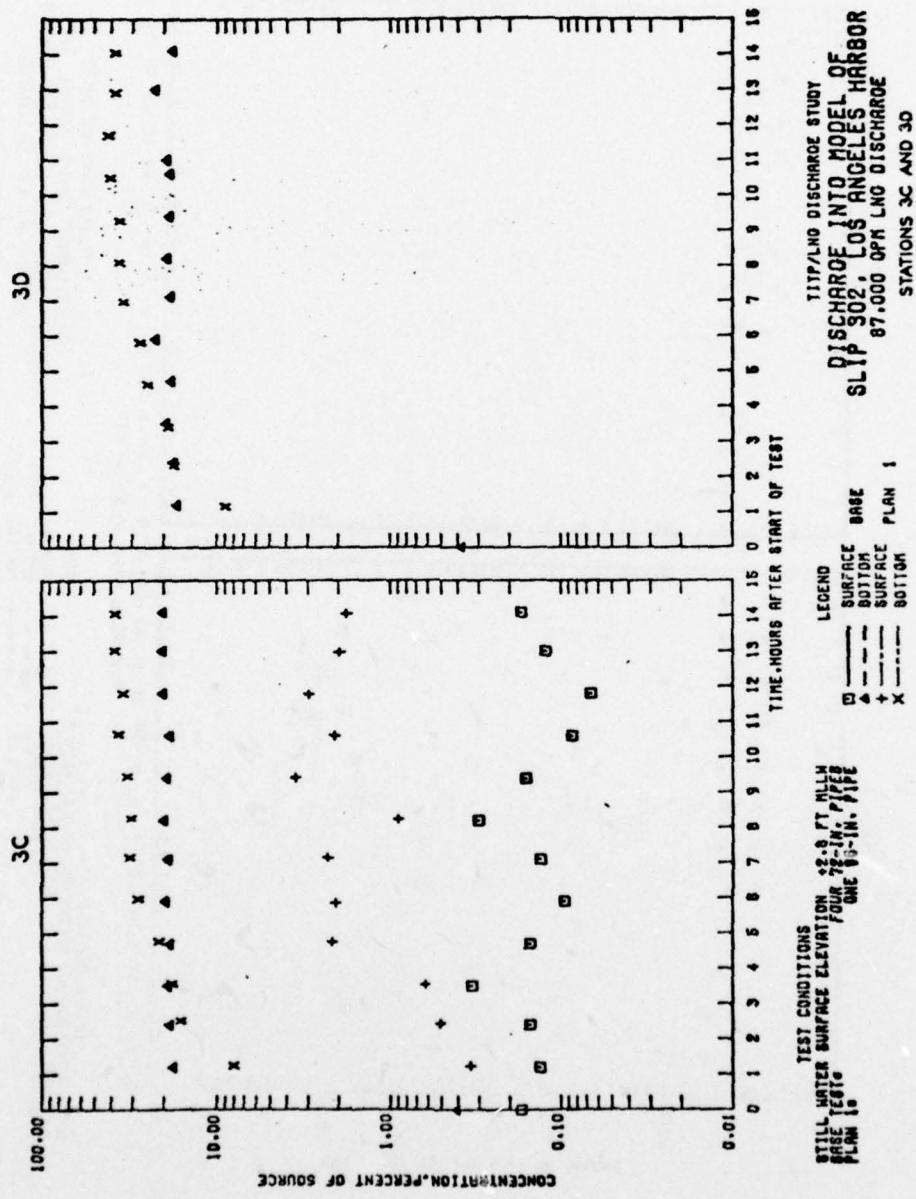
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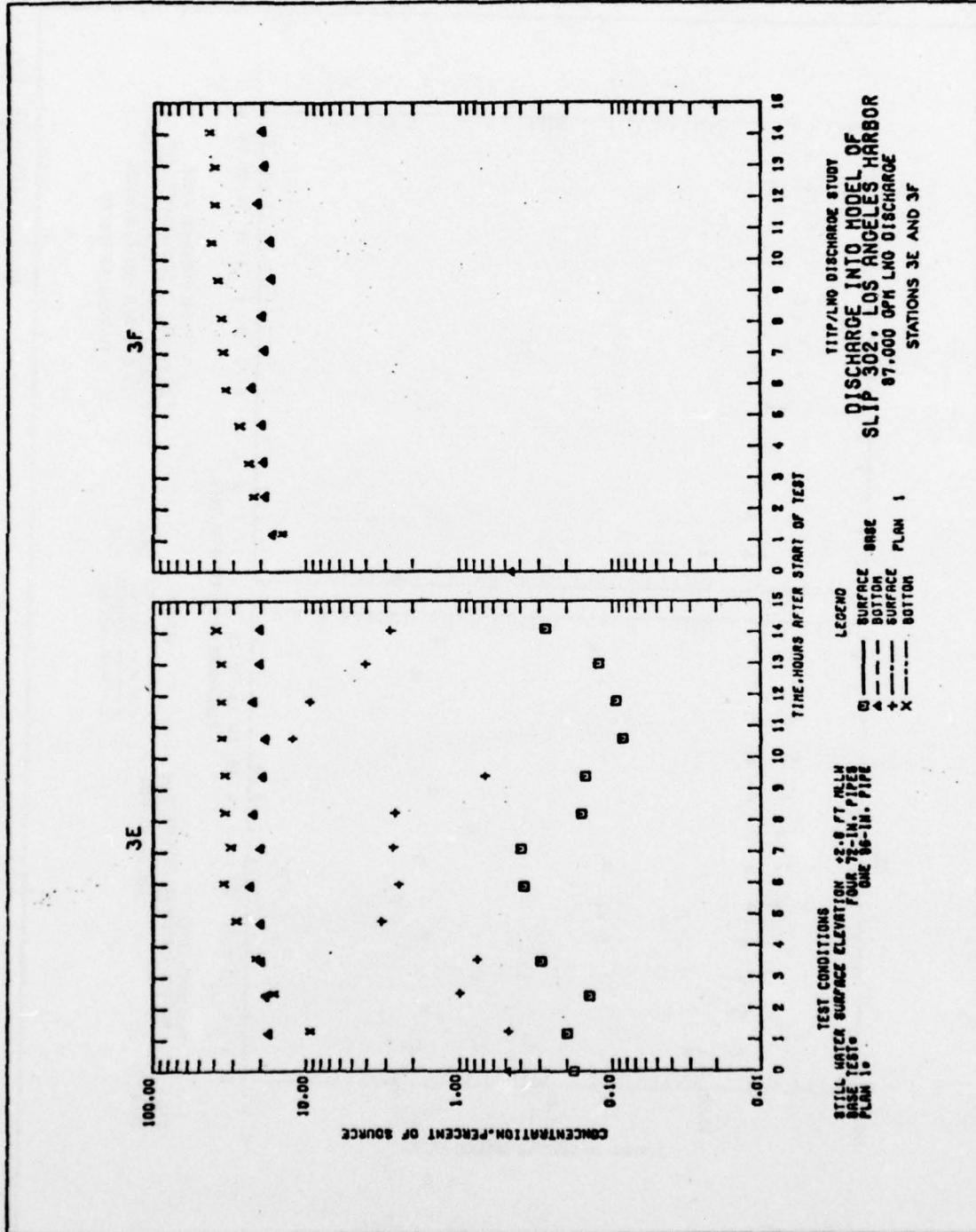
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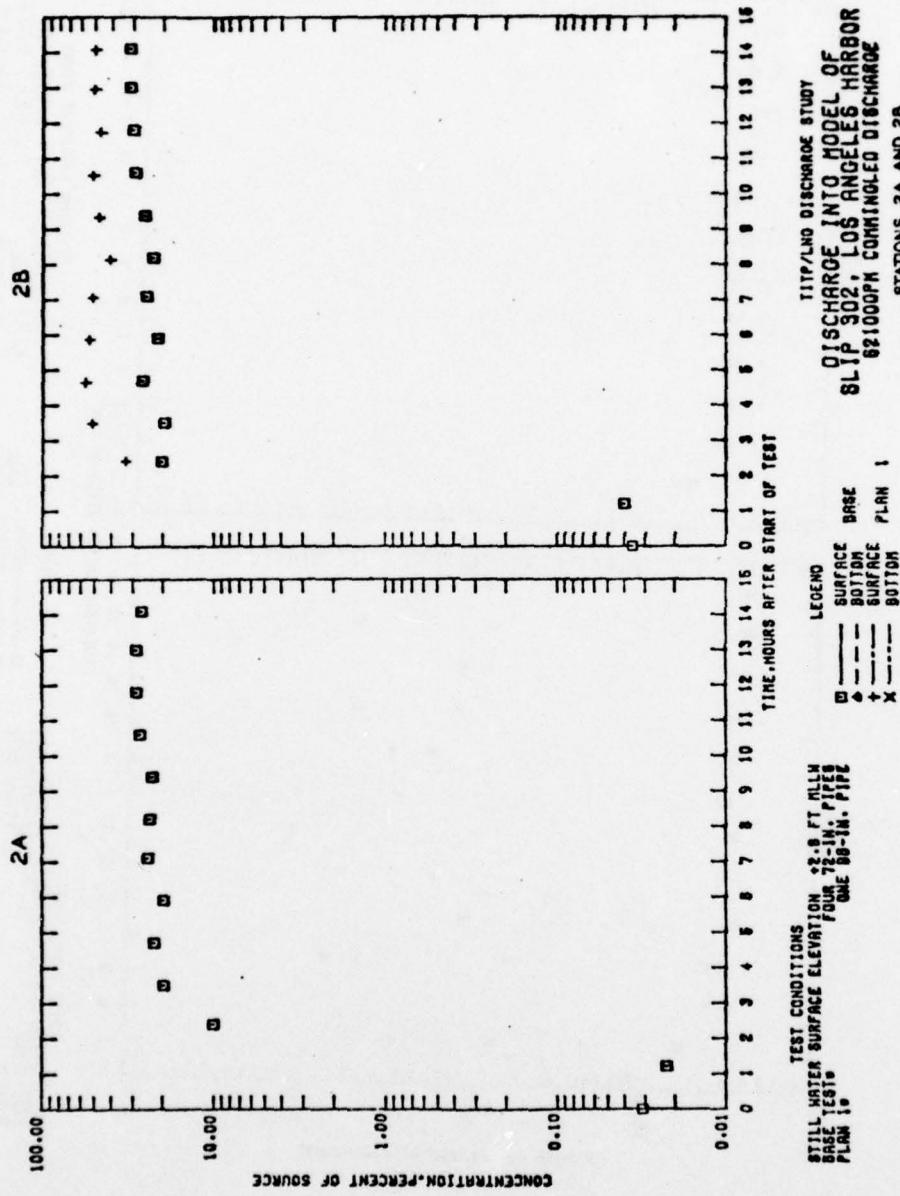


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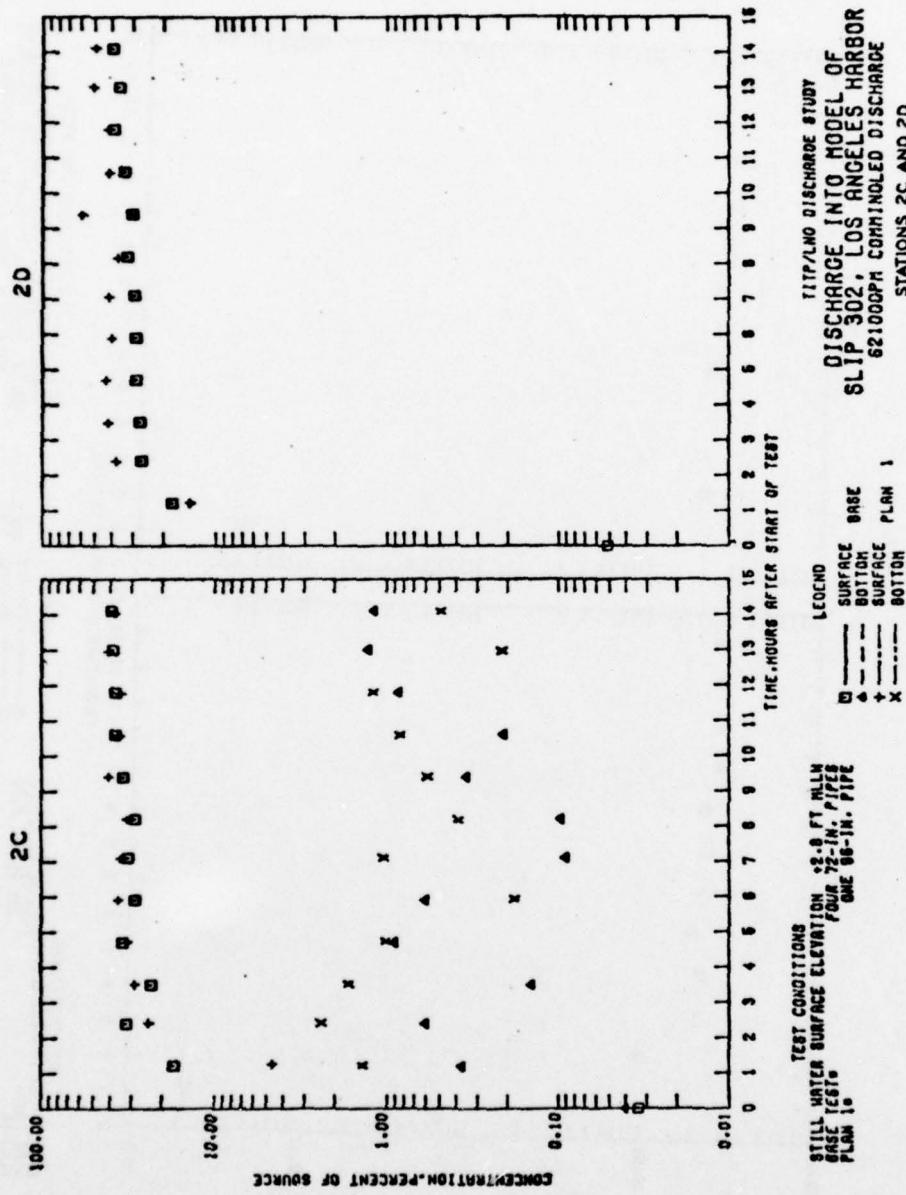
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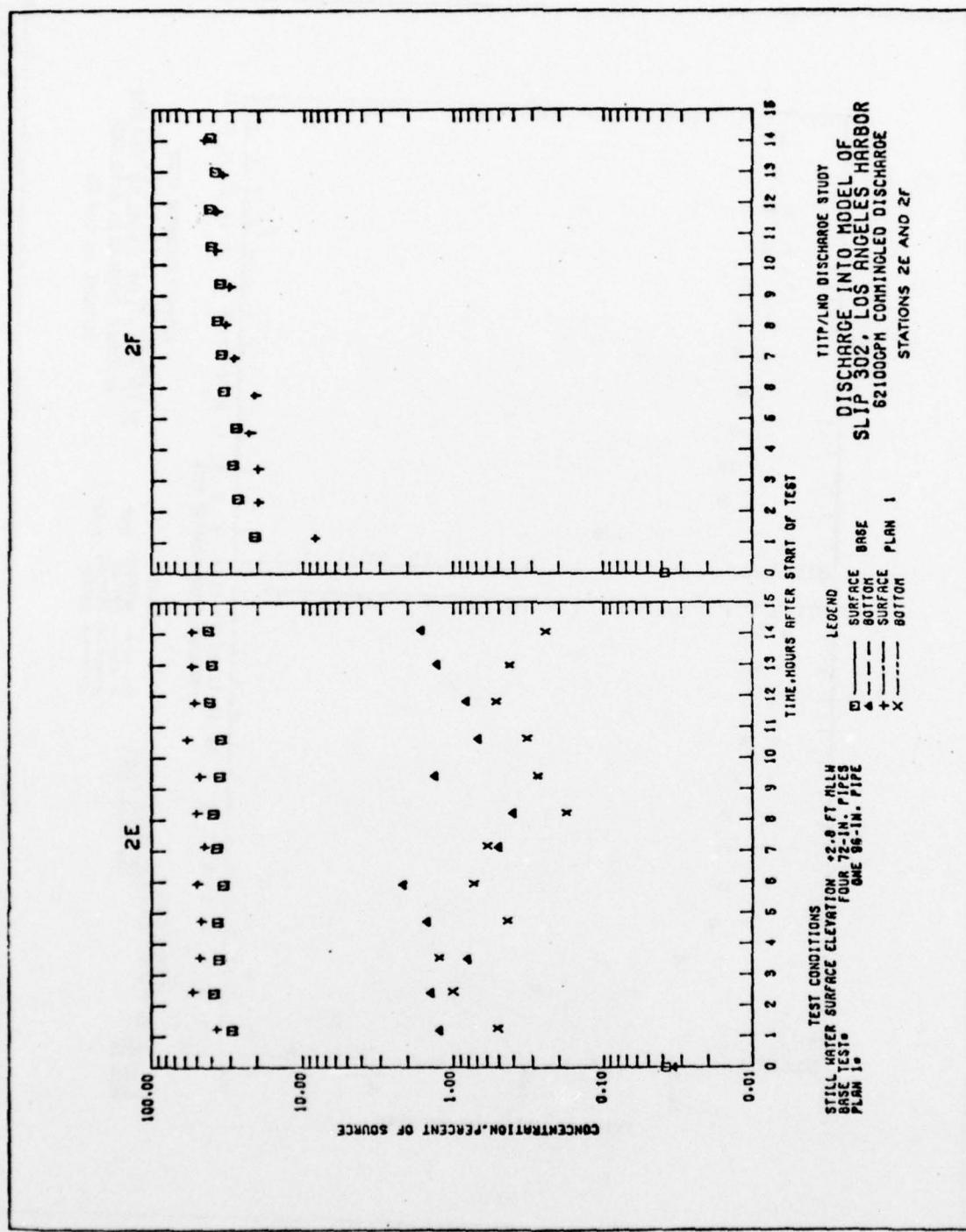


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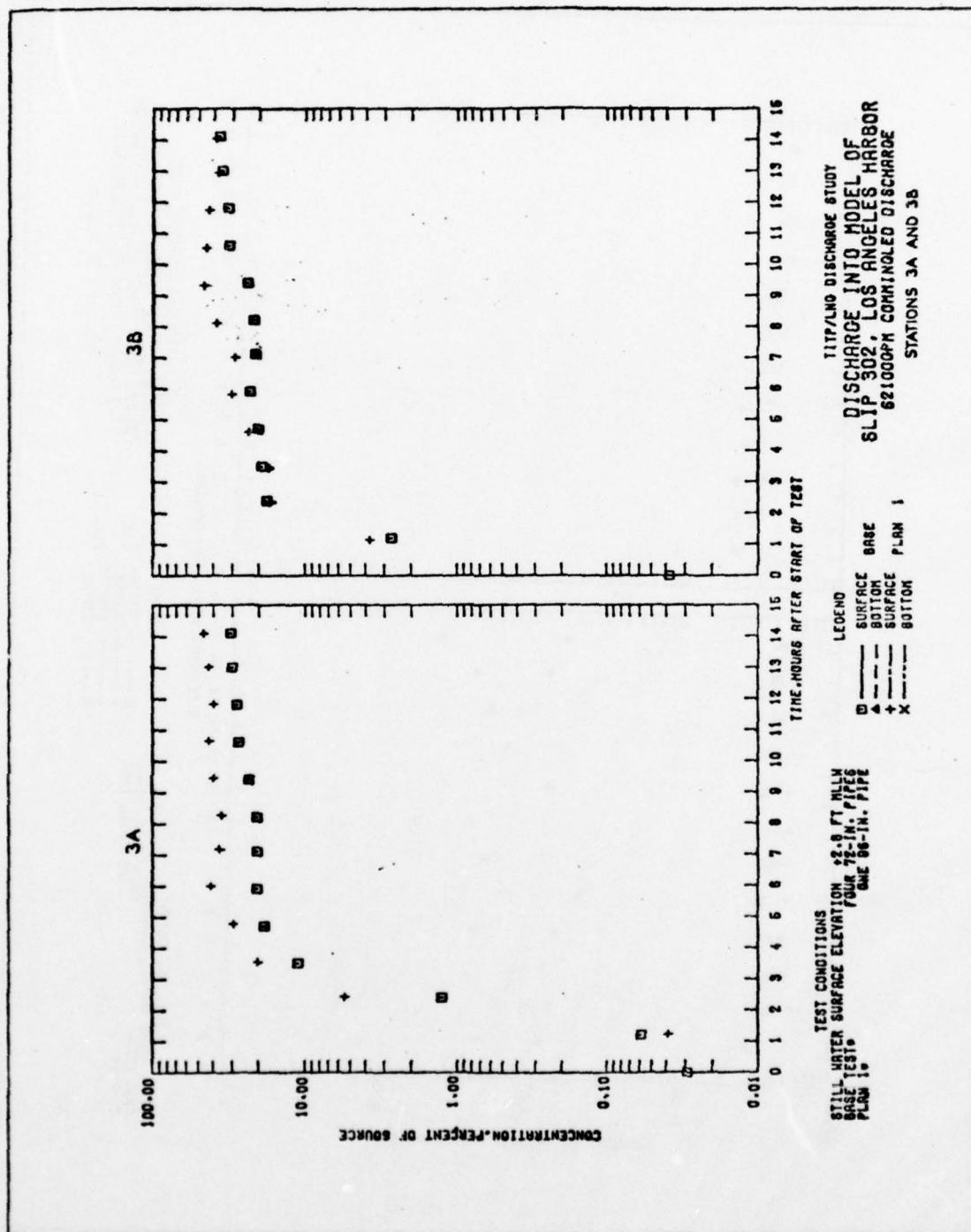
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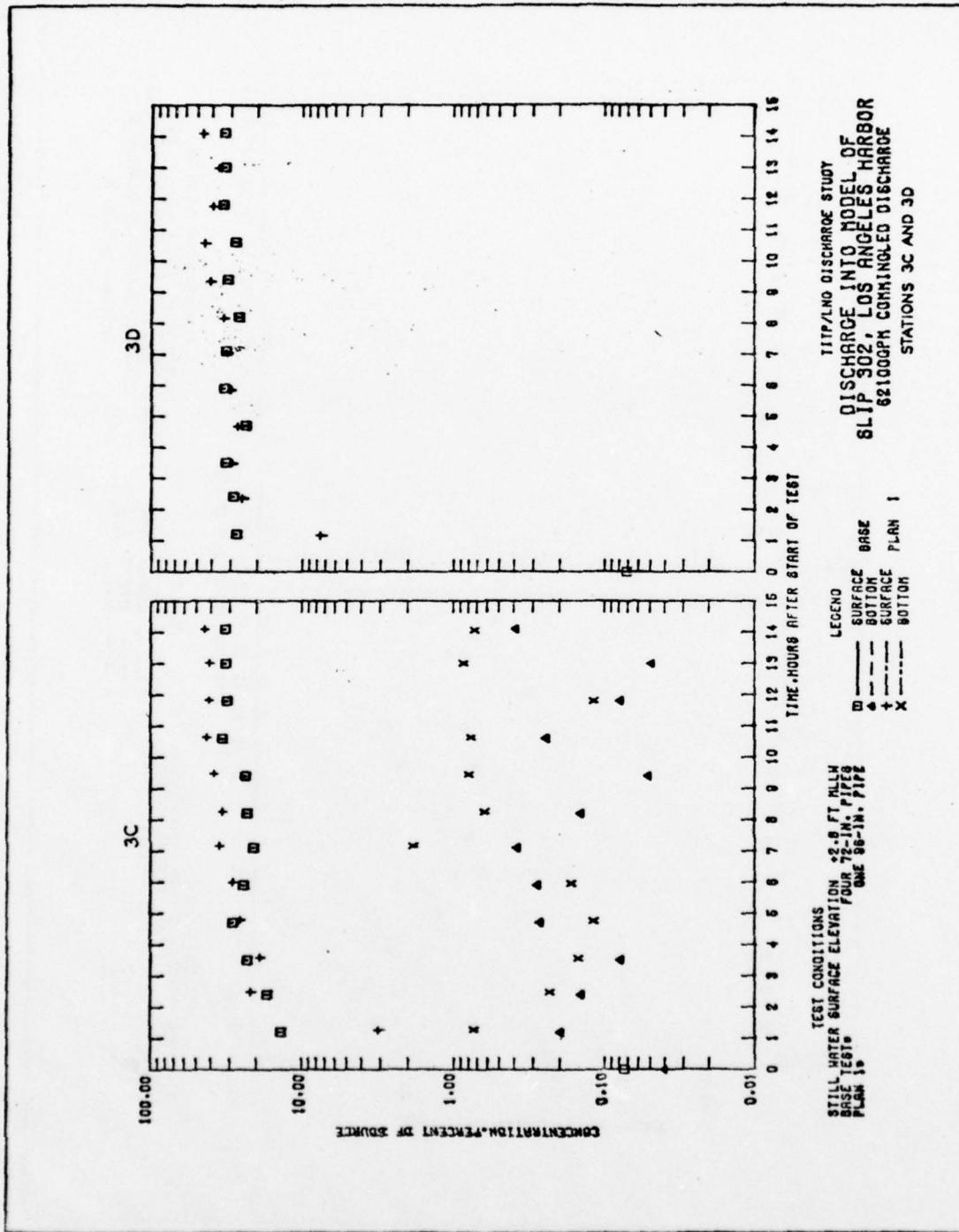
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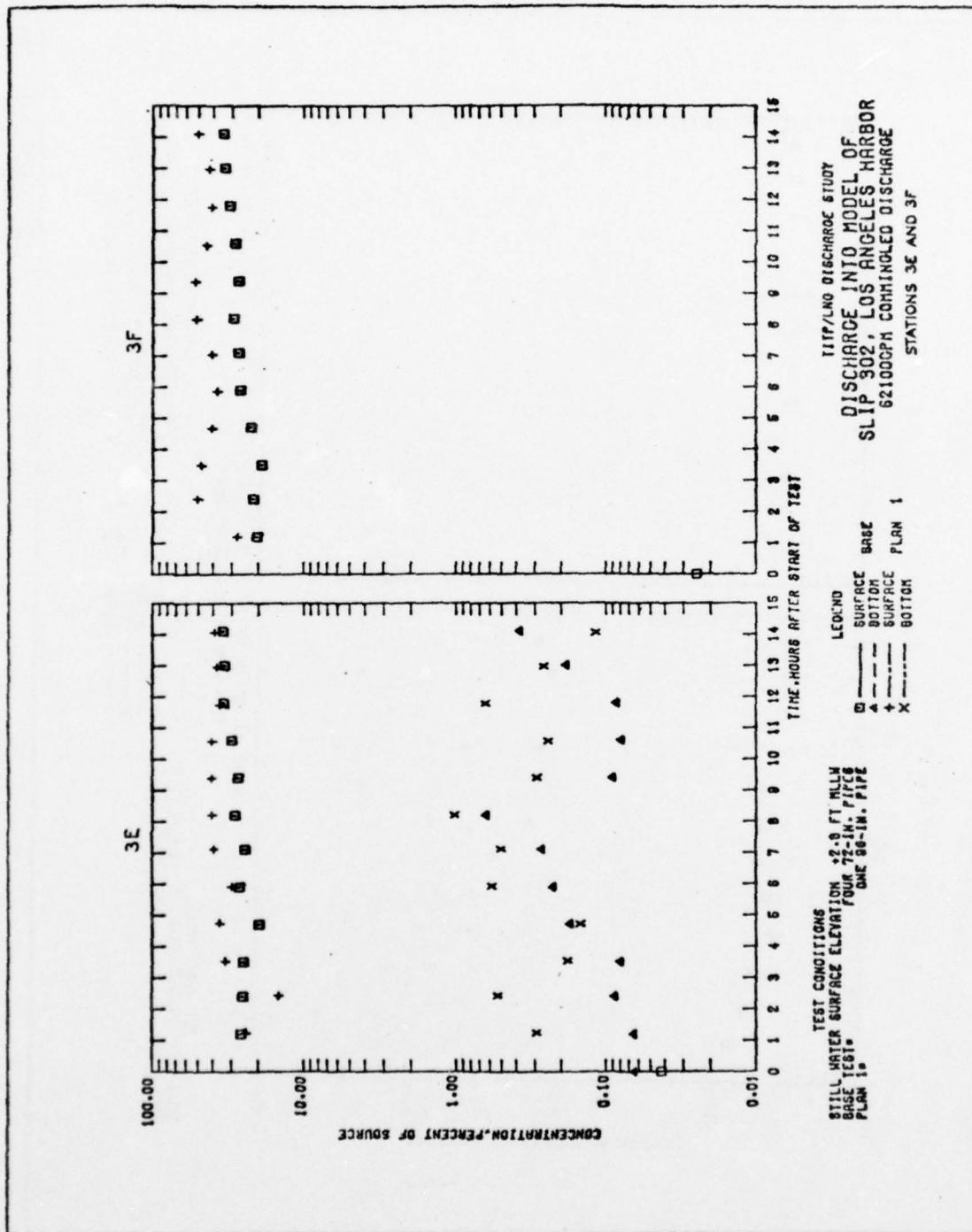
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WESHE

20 February 1976

MEMORANDUM FOR RECORD

SUBJECT: Preliminary Data from Model Study of LNG Facility Cool-Water Discharge into Los Angeles Harbor

1. This memorandum conveys preliminary data from model tests of cool-water discharge into Slip 302, Los Angeles Harbor from the Liquified Natural Gas (LNG) facility proposed for construction on Terminal Island, Los Angeles Harbor. Tests described herein were conducted at the Waterways Experiment Station (WES) during the period November 1975 through February 1976 by agreement between the Port of Los Angeles and WES.
2. Tests for the Port of Los Angeles were coordinated with model tests of discharge from the City of Los Angeles' Terminal Island Treatment Plant. Tests of the treatment plant discharge were performed by agreement between the City of Los Angeles and WES. Those model tests which were conducted solely for the City are described in this memorandum but results from those tests are not included. Reference 1 contains preliminary data from tests conducted solely for the City and those that were sponsored jointly by the City and Port.
3. These data are provided in preliminary form so that they may be available at an early date. They are subject to revision and analysis by WES. The purpose of this memorandum is to provide a basic description of the tests and data so that they may be readily understood. A formal report describing the tests in detail and analyzing the data will be published later.

Models

4. These tests were conducted in two physical hydraulic models. Near-field tests were performed in an undistorted, 1:50-scale, sectional model of the proposed slip. The slip location is shown in Figure 1, and the limits of the sectional model are illustrated by Figure 2. The model was constructed to scale according to the configuration shown in

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Fluor Ocean Services Drawing Number 702115-00-002, revised 30 July 1975, plus additional details provided by the Port of Los Angeles. The LNG facility pier was constructed to scale in the model according to Fluor Ocean Services Drawing Number 702115-00-005A dated 23 September 1975. Rock cover protecting slip side slopes was scaled to preliminary design sizes provided by the Port of Los Angeles.

5. The sectional model discharge manifold was constructed to scale reproducing a prototype design of four 6-foot-diameter pipes passing through the north end of the slip with a center-line elevation of -12 feet mllw and spaced in a line at 75 feet on centers. The discharge pipes were arranged symmetrically about the center line of the slip's bottom width, and the axis of each pipe was parallel to the center line.

6. Far-field tests were conducted in the WES comprehensive Los Angeles-Long Beach Harbors model, which has length scales of 1:100 vertically and 1:400 horizontally. The comprehensive model and its tidal verification are described in Reference 2.

7. The discharge manifold used in the comprehensive model consisted of four rectangular ports 0.14 inch wide and 0.72 inch high installed in the location described in Paragraph 5.

8. The comprehensive model configuration during these tests was that designated as Plan 1A3 of the harbors development. Plan 1A3 consists of dredging and landfill construction in both harbors as shown in Figure 1.

Tests Description

9. Three discharge plans were tested as described in Reference 3. The plans were 18,000-gpm sewer discharge alone at 10 ppt salinity and 76°F; 62,100-gpm commingled sewer and LNG discharges at 27 ppt salinity and 56°F; and 87,000-gpm LNG facility discharge alone at 34 ppt and 56°F. Average ambient conditions were taken to be 34 ppt salinity and 60°F.

10. Each plan was tested in both sectional and comprehensive models. Multiple tests were conducted to permit collection of the desired data. A brief description of each test and the data acquired is given in Table 1.

11. In the sectional model tests, the water surface was held constant at the mean tide level, +2.8 feet mllw. The density difference between effluent and receiving water was achieved by varying their relative

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20 February 1976

SUBJECT: Preliminary Data from Model Study of LNG Facility Cool-Water Discharge into Los Angeles Harbor

salinities. In each case, the controlling parameter was the density ratio in the densimetric Froude number--the difference in density between effluent and receiving waters divided by receiving water density. Since other scales were determined by Froudian relationships, densimetric Froude numbers were the same in model and prototype.

12. A conservative fluorescent dye was added to the sectional model effluent so that it might be traced in the model. Water samples were withdrawn from 13 stations (see Figure 2) in the model at 70-minute (prototype) intervals for an equivalent 14.1 prototype hours. Surface or bottom samples were taken at every station, depending upon which plan was being tested, and both surface and bottom samples were taken at Stations 2C, 2E, 3C, and 3E. Samples were withdrawn from several depths at Station 2D to define the effluent plume interface. The water samples were analyzed to determine dye content and thus the degree of dilution of the plume.

13. In the comprehensive model tests, density differences were obtained by heating the effluent to create a surface plume or by adding salt to create a bottom plume. The effluent plume's temperature or salinity was adjusted until the proper density at Station 2D was obtained. The proper density was that providing the density ratio (Paragraph 11) computed from dye tracer results in the sectional model. A mean tide (5.4-foot diurnal range) was used in all comprehensive model tests.

14. Color movies of the dyed effluent plume were obtained in the comprehensive model by means of a time-lapse camera with a 2-second framing interval. Color slides were taken of the plume at regular intervals.

15. Dye tracer tests in the comprehensive model were similar to those of the sectional model. Water samples were withdrawn from 24 stations (see Figures 1 and 3) for dye concentration measurement. Table 2 lists the sampling stations and the depths at which samples were taken.

Data Description

16. The mean tide used in the comprehensive model tests is plotted in Plate 1.

17. The viewpoint of the camera for the slides and movies was from outside the breakwater, looking downward and to the north of Los Angeles Harbor. Proposed landfill areas are covered with gravel and proposed dredged areas are outlined in black. In the lower left corner of the

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20 February 1976

SUBJECT: Preliminary Data from Model Study of LNG Facility Cool-Water Discharge into Los Angeles Harbor

frame are signs identifying the test number, number of elapsed tidal cycles, and elapsed hours of the present cycle. Projecting the movies at normal speeds greatly speeds motion of the dye cloud.

18. Results of dye tracer tests in both models are illustrated in the plates as plots of dye concentration versus time. Dye concentration is expressed as a percent of source concentration. For the sectional model tests, the source concentration is the actual measured dye concentration in the effluent before discharge. In the comprehensive model tests, an equivalent source concentration has been computed by taking the absolute dye concentration at Station 1 to be equivalent to the concentration at the corresponding station (Station 2D) in the sectional model test. Thus the plotted percent of source concentration represents the tracer concentration that would have resulted if the comprehensive model reproduced near-field plume behavior correctly.

19. Current velocities were measured at Range 8 (see Figure 1) in the comprehensive model so that the effect of the plans upon net flow through the Cerritos Channel could be determined. Measured velocities are plotted in Plates 2, 3, and 4 against base velocities (no discharge). Apparent net discharges for Range 8 were computed by the technique described in Reference 2 and are shown in Table 3.

20. Center-line current velocities were measured at Station 2D in the sectional model by measuring the transit time of floats over a measured distance. Current velocities measured in the sectional model are being checked for accuracy and will be forwarded separately.

Limitations of the Data

21. Analysis of the errors present in the accompanying data is beyond the scope of this memorandum, but it is appropriate to include a brief description of the data's limitations.

22. Dilution of the dye tracer in the sectional model tests is considered to be an accurate and reliable indication of effluent dilution in the prototype under similar conditions. Several deviations from these conditions that could or would occur in the prototype, such as uneven flow splitting in the manifold, tidal- or wind-induced water surface fluctuations, ambient water stratification, variations in discharge rate, and vessel transit, were not reproduced in the sectional model. While such deviations would cause dilution changes, the sectional model results are a good representation of an average condition.

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SUBJECT: Preliminary Data from Model Study of LNG Facility Cool-Water Discharge into Los Angeles Harbor

23. Dye tests in the comprehensive model show where the **diluted effluent** will be transported, but note that the comprehensive model has not been verified for dispersive transport, i.e., the model has not been proven to accurately reproduce the dispersion of a tracer. This means that at distances far enough from the source for transverse and longitudinal dispersion to significantly affect concentration and where vertical stratification breaks down, dye concentrations may not represent concentrations that would occur in the prototype. However, past experience indicates that the relative distribution of tracer along the dye cloud path tends to be a fairly accurate representation of what would occur in the prototype under similar conditions. Where a strong stratification exists within constraining lateral boundaries, the model is assumed to accurately reproduce prototype behavior.

24. During Test CM3D (62,100-gpm commingled discharge), a malfunction of equipment used to heat the effluent occurred at about Cycle 30. For this reason, data for Test CM3D between Cycles 30 and 40 should be disregarded.

W H McAnally Jr

3 Att
Tables 1-3
Figures 1-3
Plates 1-4, L1-L71,
and SL1-SL70

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Engineer
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REFERENCES

1. U. S. A. E. Waterways Experiment Station, Memorandum for Record, Subject: Preliminary Data from Model Study of Terminal Island Treatment Plant (TITP) Effluent Discharged into Los Angeles Harbor, 19 February 1976.
2. McAnally, W. H., Jr., Los Angeles-Long Beach Harbors Model, Report 5, Tidal Verification and Base Tests, TR-H-75-4, U. S. A. E. Waterways Experiment Station, September 1975.
3. U. S. A. E. Waterways Experiment Station, Memorandum for Record, Subject: Model Tests of Discharges into Proposed LNG Slip, Los Angeles Harbor, 29 October 1975.

TABLE 1
Summary of Tests Performed

Plan Description	Test No.	Duration (Prototype)	Model	Data Description
Sewer discharge only 18,000 gpm @ 16°F above ambient temperature and 10 ppt salinity	SM4	14.1 hrs	Sectional	Percent dye concentration plots, Plates S1-S8A
	SM4V	-	Sectional	Center-line velocities, Table 4
	CM4	9 cycles	Comprehensive	Movie and slides of dye cloud
	CM4A	1 cycle	Comprehensive	Surface current pattern photographs, Plates S9-S20
Commingled sewer and LNG facility discharges 62,100 gpm @ 4°F below ambient temperature and 27 ppt salinity	SM3	14.1 hrs	Sectional	Percent dye concentration plots, Plates SL1-SL8A
	SM3V	-	Sectional	Center-line velocities, Table 4
	CM3A	8 cycles	Comprehensive	Movie and slides of dye cloud
	CM3D	61 cycles*	Comprehensive	Percent dye concentration plots and net flow through Cerritos Channel, Plates SL9-SL70, Table 3
LNG facility discharge only. 87,000 gpm @ 4°F below ambient temperature and ambient salinity	SM5	14.1 hrs	Sectional	Percent dye concentration plots, Plates L1-L9A
	SM5V	-	Sectional	Center-line velocities, Table 4
	CM5A	9 cycles	Comprehensive	Movie and slides of dye cloud
	CM5D	81 cycles*	Comprehensive	Percent dye concentration plots and net flow through Cerritos Channel, Plates L10-L71, Table 3

* No effluent discharged during last 10 tidal cycles of test.

TABLE 2
Water Sample Depths for Tests CM3D and CM5D

Station No.	Fraction of Low-Water Depth Below Water Surface				
	2%	25%	50%	75%	*98%
1	X	X	X	X	X
2	X	X	X	X	X
3	X				X
4	X				X
5	X	X	X	X	X
6	CM3D				
7	X				X
8	X	X	X	X	X
9	X				X
10	X	X	X	X	X
11	X				X
12	X				
13	X	X	X	X	X
14	X				X
15	X				X
16A	X				X
16B	X				X
17	X				X
18	X	X	X	X	X
19	X				X
20	CM3D				
21	CM3D				
22	CM3D				
23	CM3D				

*Constant 1 ft (prototype) above bottom

TABLE 3

Apparent Net Discharge Per Tidal Cycle at Range 8

<u>PLAN</u>	<u>NET. DISCHARGE (10^6 cu ft)</u>
1A3 - Base, Mean Tide	+87
1A3 - 62,100-gpm Commingled Discharge	+158
1A3 - 87,000-gpm LNG Discharge	+94

NOTE: Positive values indicate net flood flows.

PRELIMINARY DATA

TABLE 4
CENTERLINE VELOCITIES IN PROTOTYPE FPS
SECTIONAL MODEL TESTS

TEST NO.	SURFACE	MIDDEPTH	BOTTOM
SM3V	+0.17	+0.06*	-0.01*
SM4V	+0.05	+0.04*	-0.01*
SM5V	+0.18	**	**

*Values possibly contaminated by multi-layer flow causing erroneous readings

**Values not presented because of strong possibility of contamination by
multi-layer flow

NOTE: Positive sign indicates flow out of the slip; negative sign indicates
flow into the slip

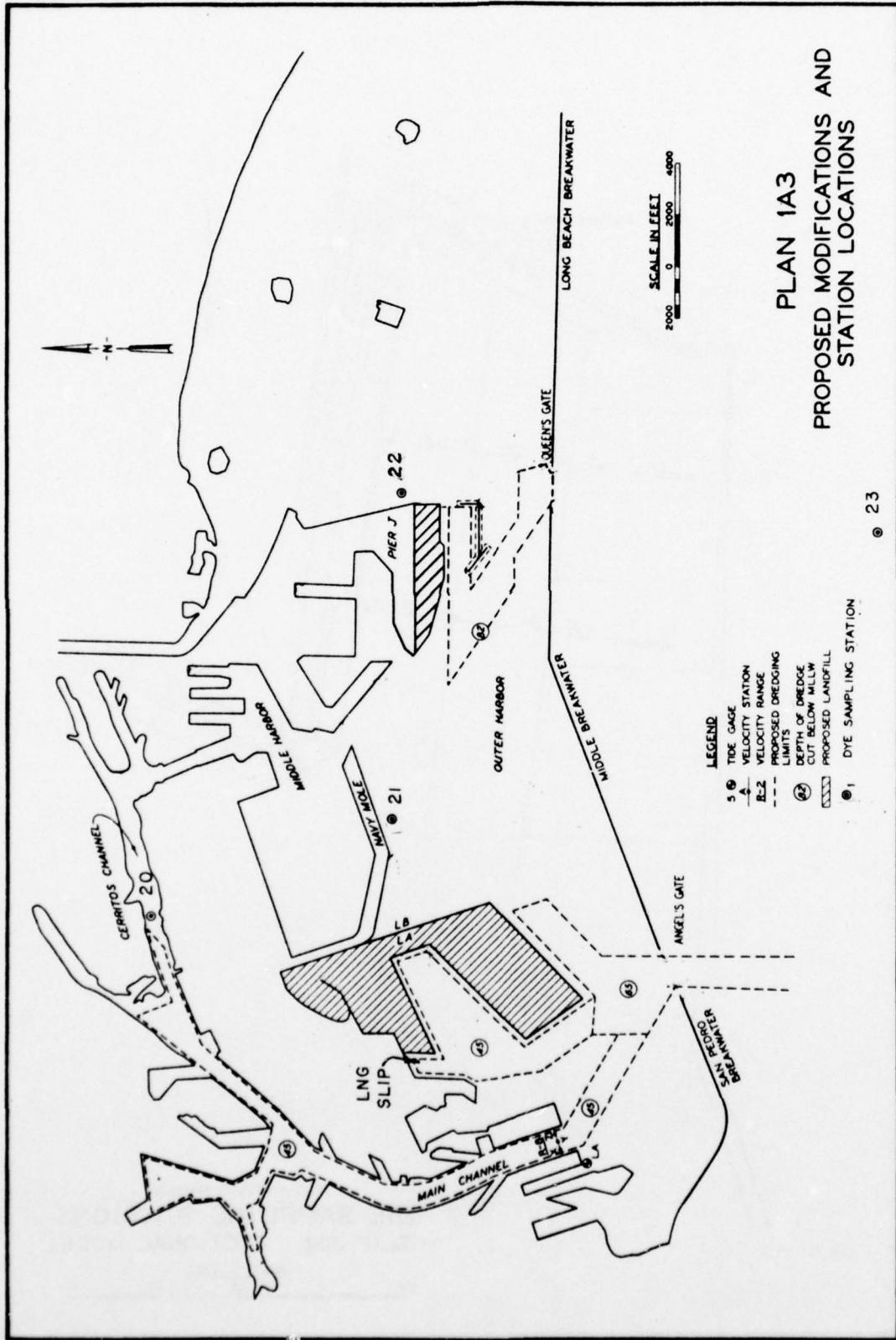


FIGURE I

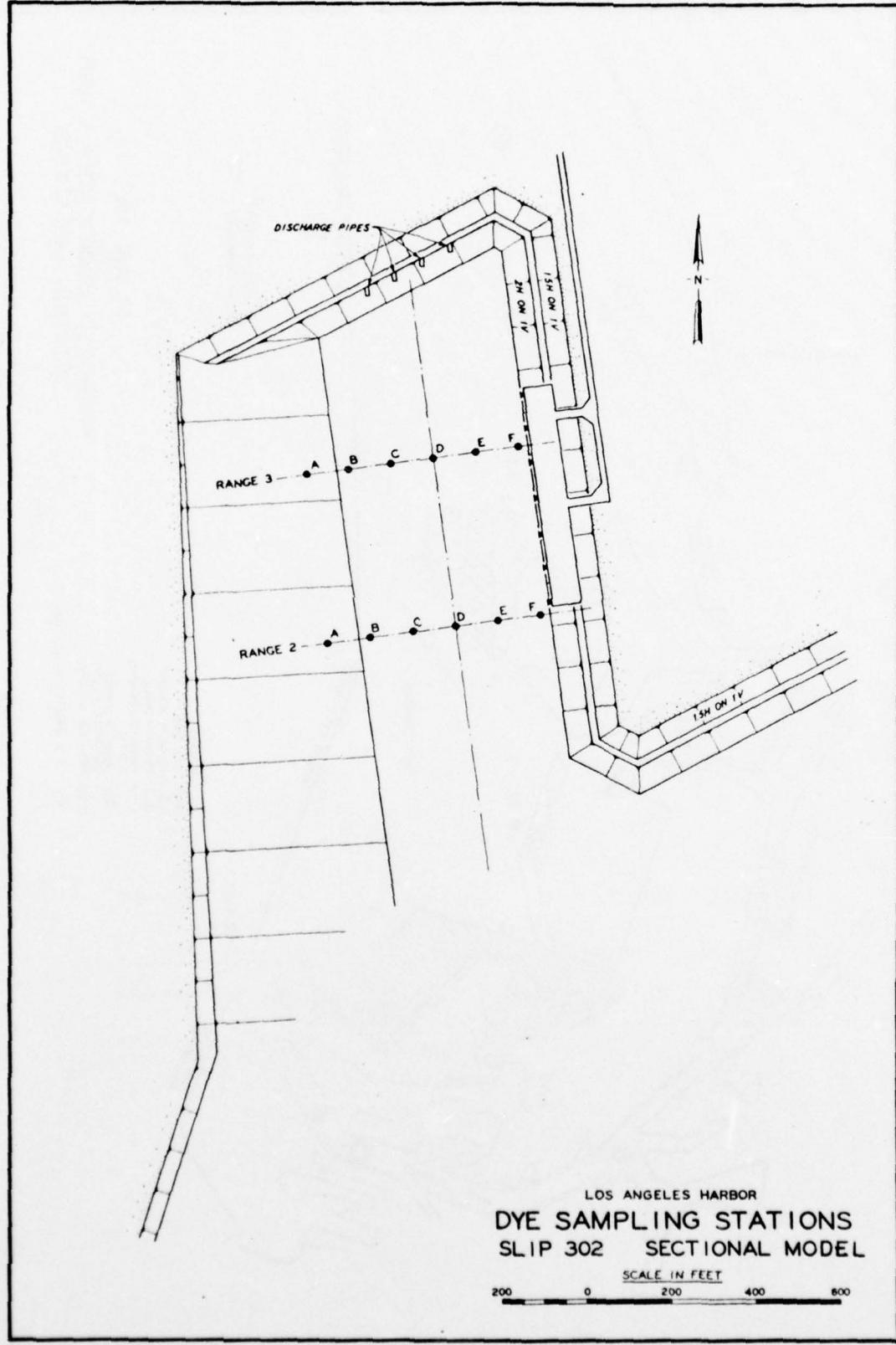
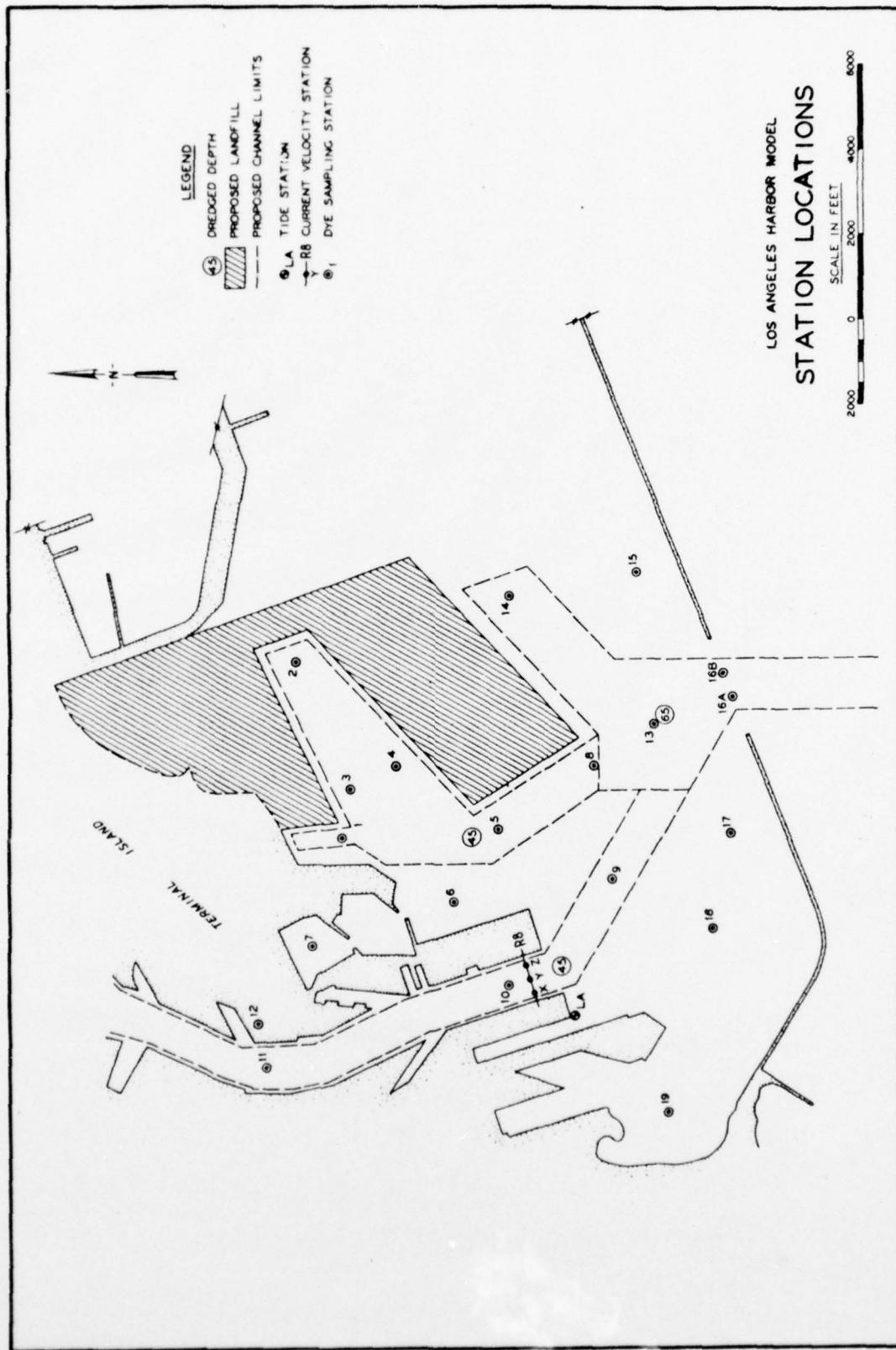
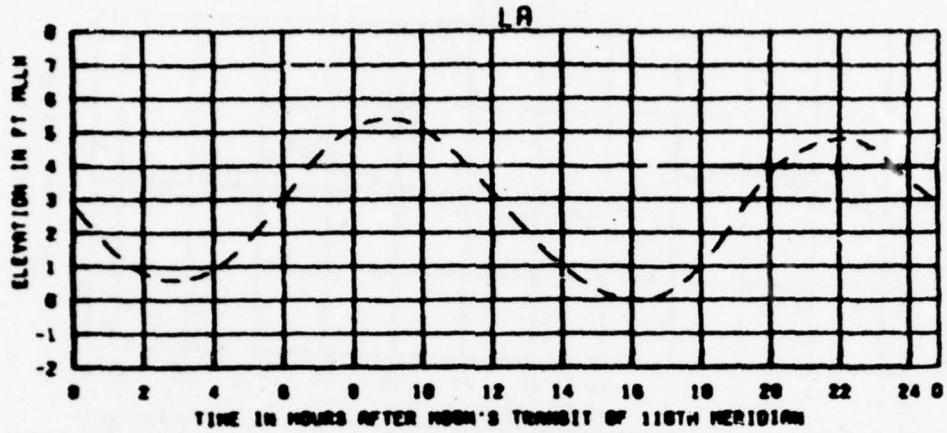


FIGURE 2

FIGURE 3





TEST CONDITIONS
TIDAL RANGE AT GUNNIS BAY = 6.6 FT

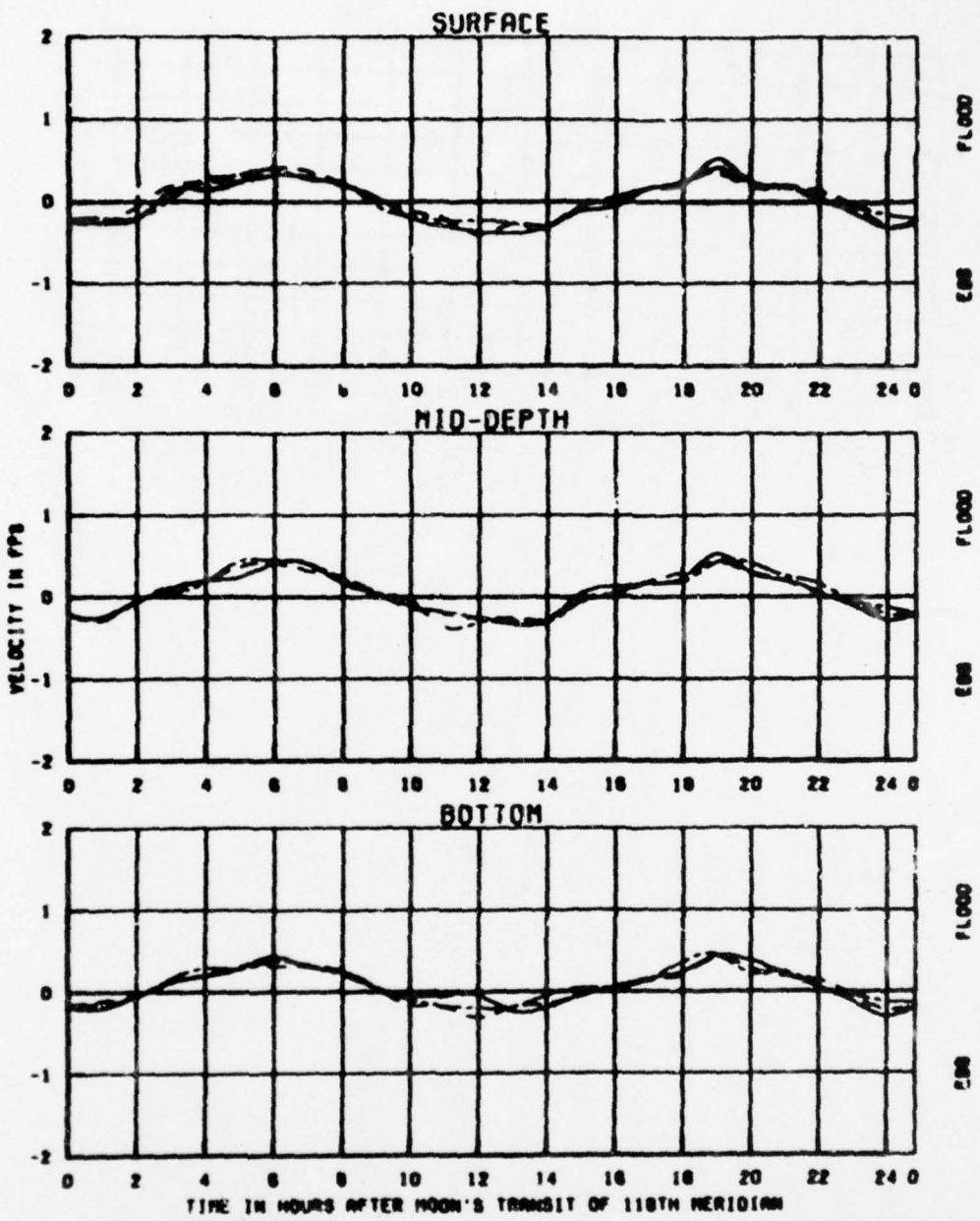
LOS ANGELES-LONG BEACH HARBOURS
PLATE 143

TIDAL ELEVATIONS
SEWER/LNG DISCHARGE
MEAN TIDE

STATION
LA

LEGEND
MODEL -----

PRELIMINARY DATA
PLATE 1



TEST CONDITIONS
TIDAL RANGE AT QUEENS BAY = 5.4 FT

LOS ANGELES-LONG BEACH HARBOURS
PLAN 1A3

VELOCITIES
SEWER/LNG DISCHARGE
MEAN TIDE

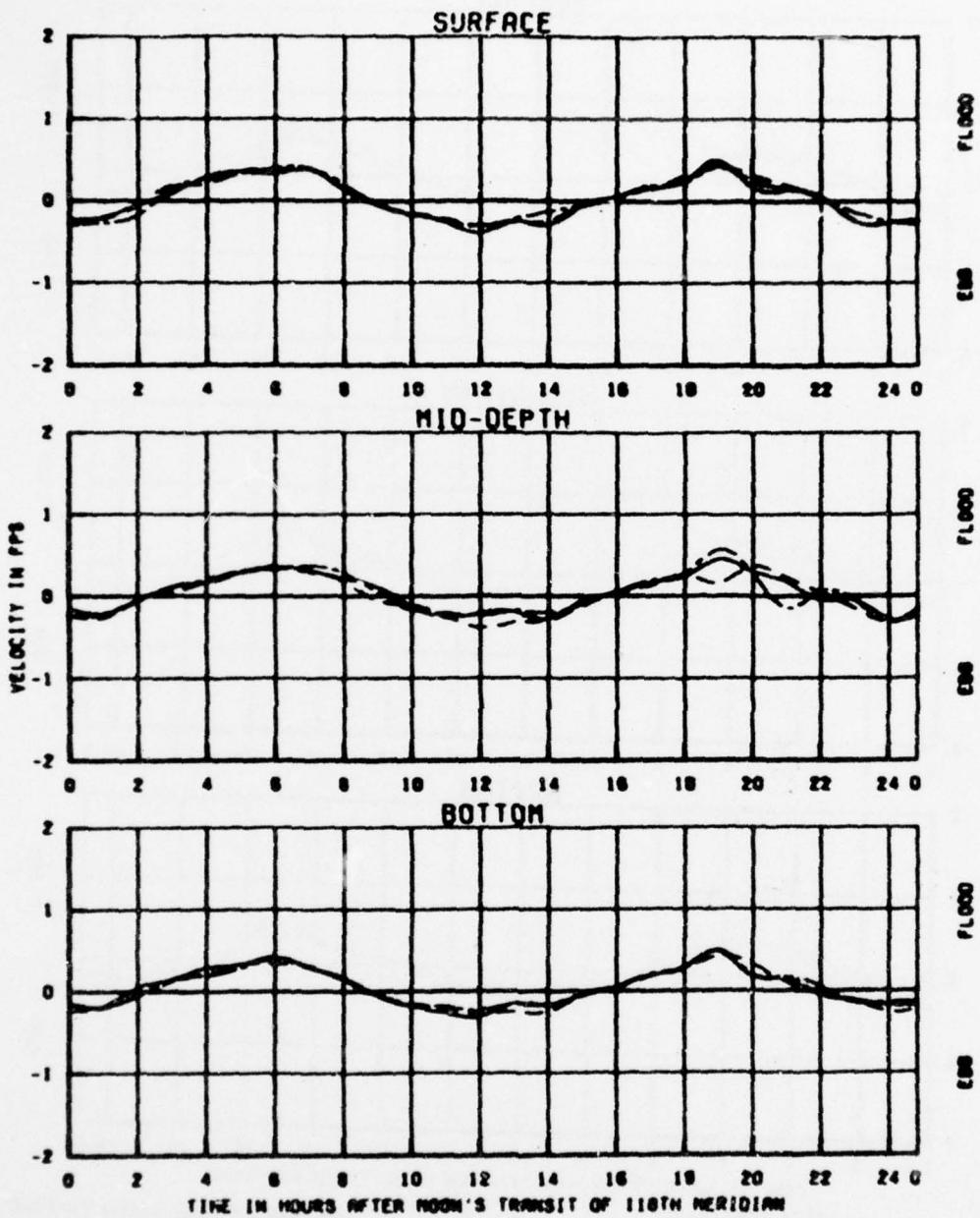
STATION
8X

LEGEND

- BASE —————
- CM3D -----
- CM5D -·-

PRELIMINARY DATA

PLATE 2



TIME IN HOURS AFTER MOON'S TRANSIT OF 116TH MERIDIAN

TEST CONDITIONS
TIDAL RANGE AT QUEENS GATE = 6.4 FT

LOS ANGELES-LONG BEACH HARBOURS
PLAN 103

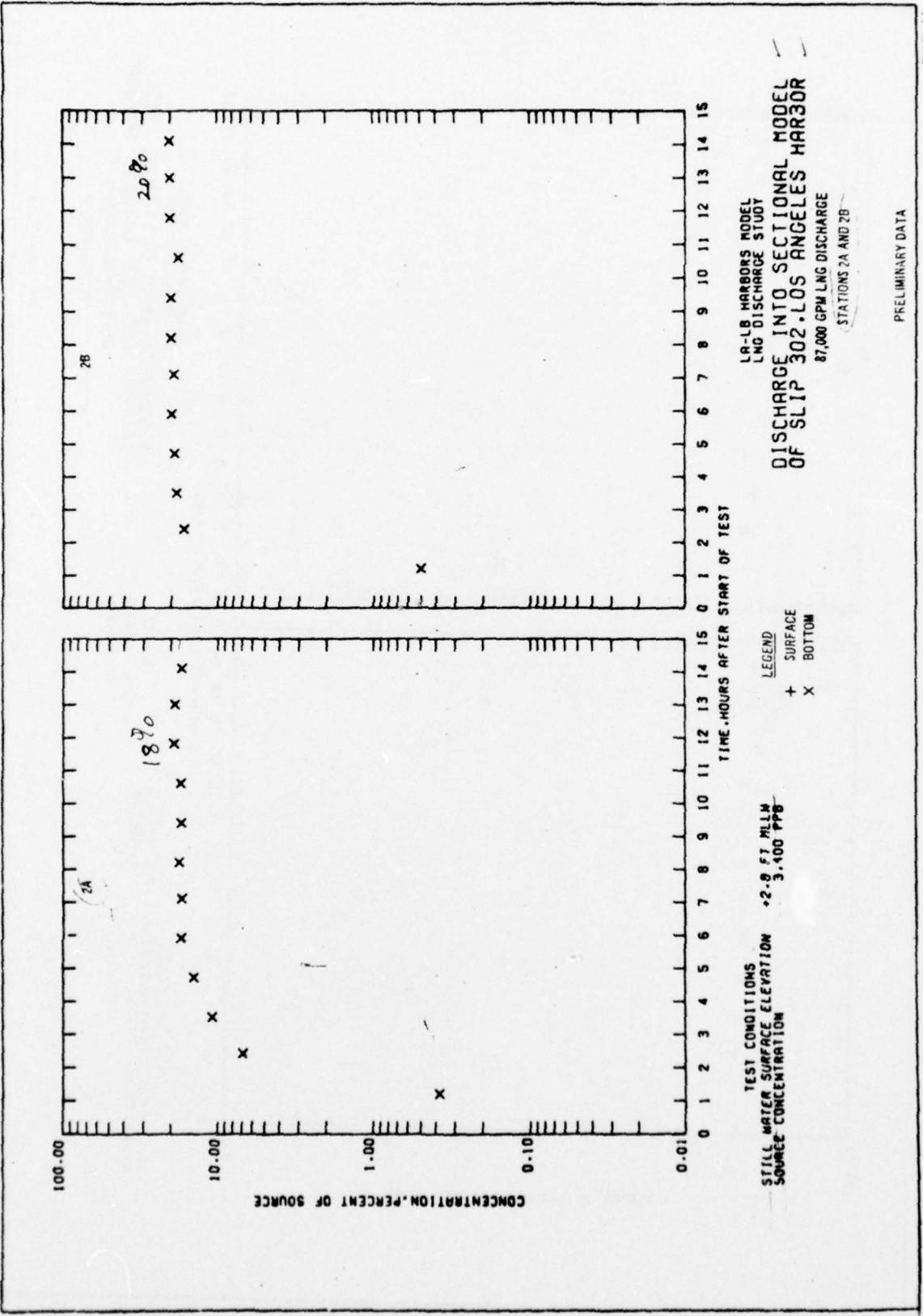
VELOCITIES
SEMER/LNG DISCHARGE
MEAN TIDE

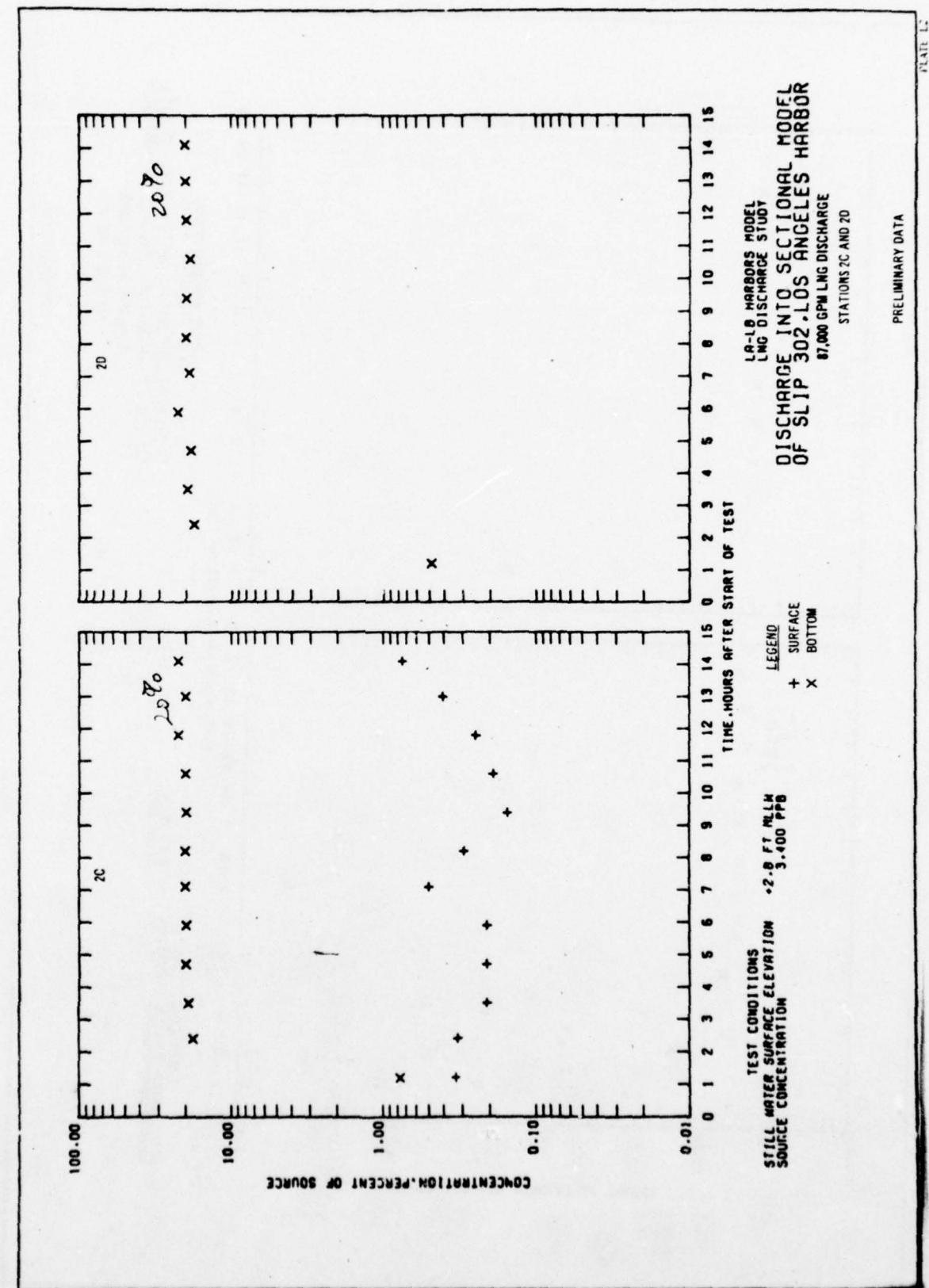
LEGEND

BASE —————
CM3D - - -
CM5D - · -

STATION
8Y

PLATE 3
PRELIMINARY DATA





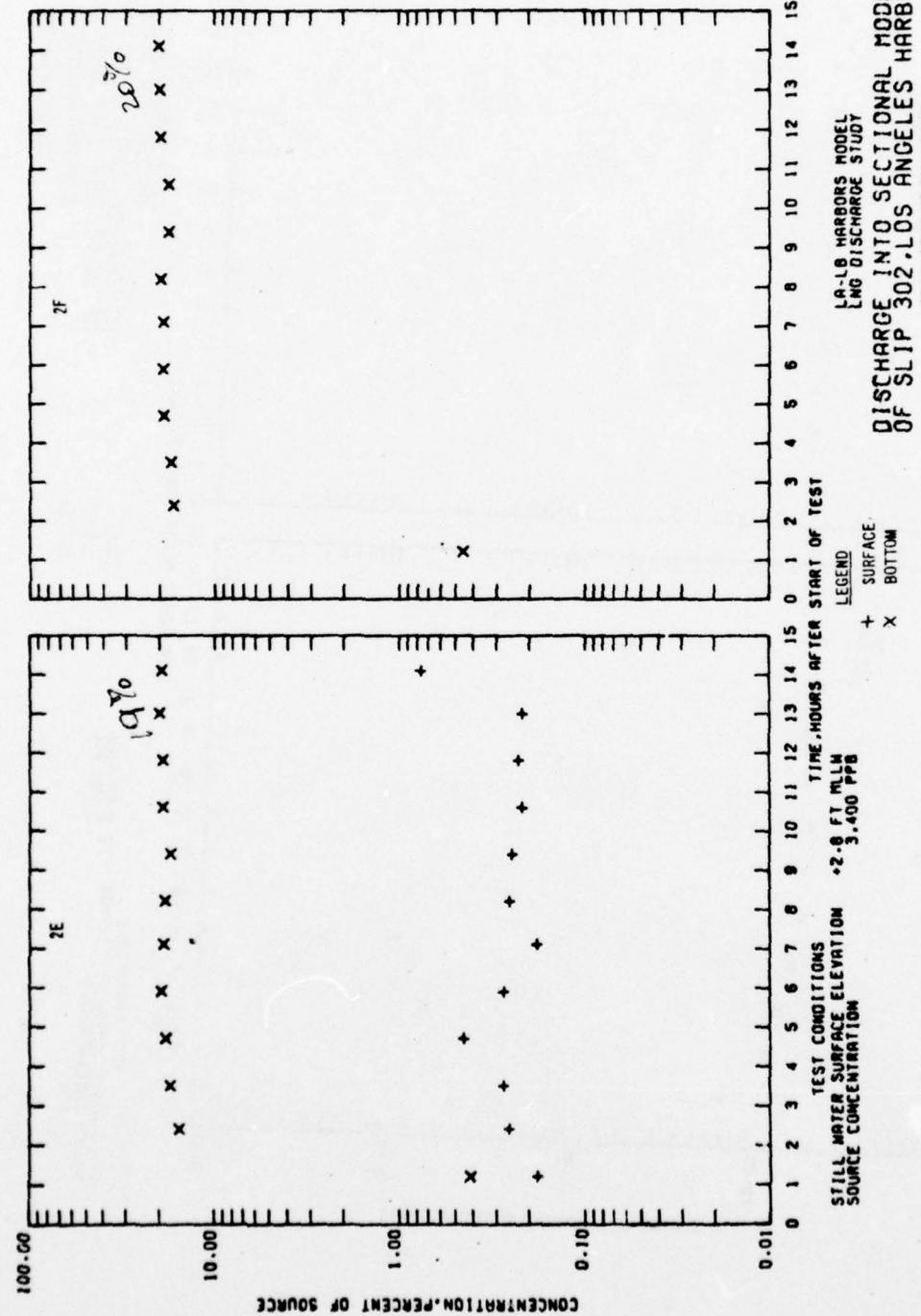
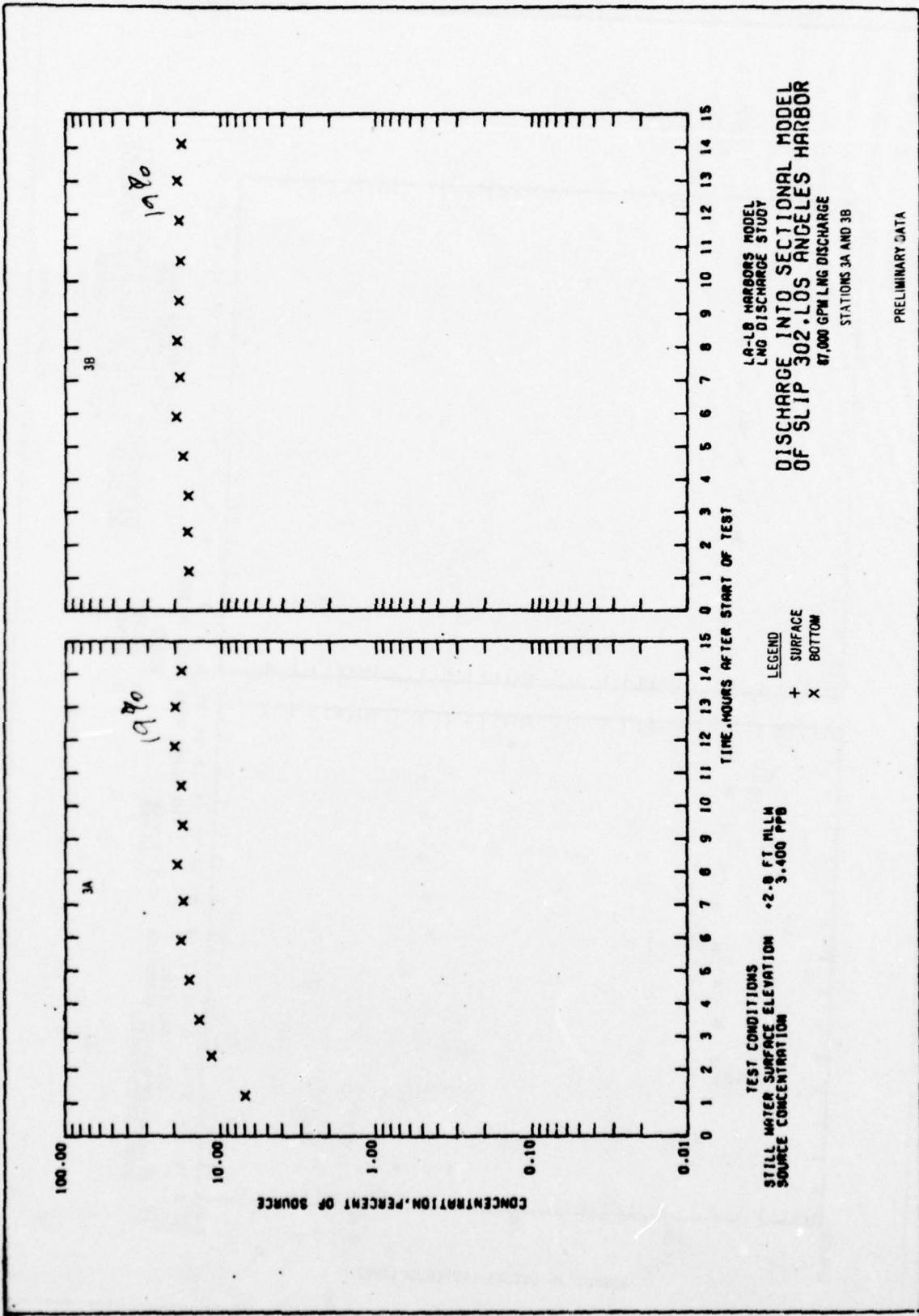


PLATE L5



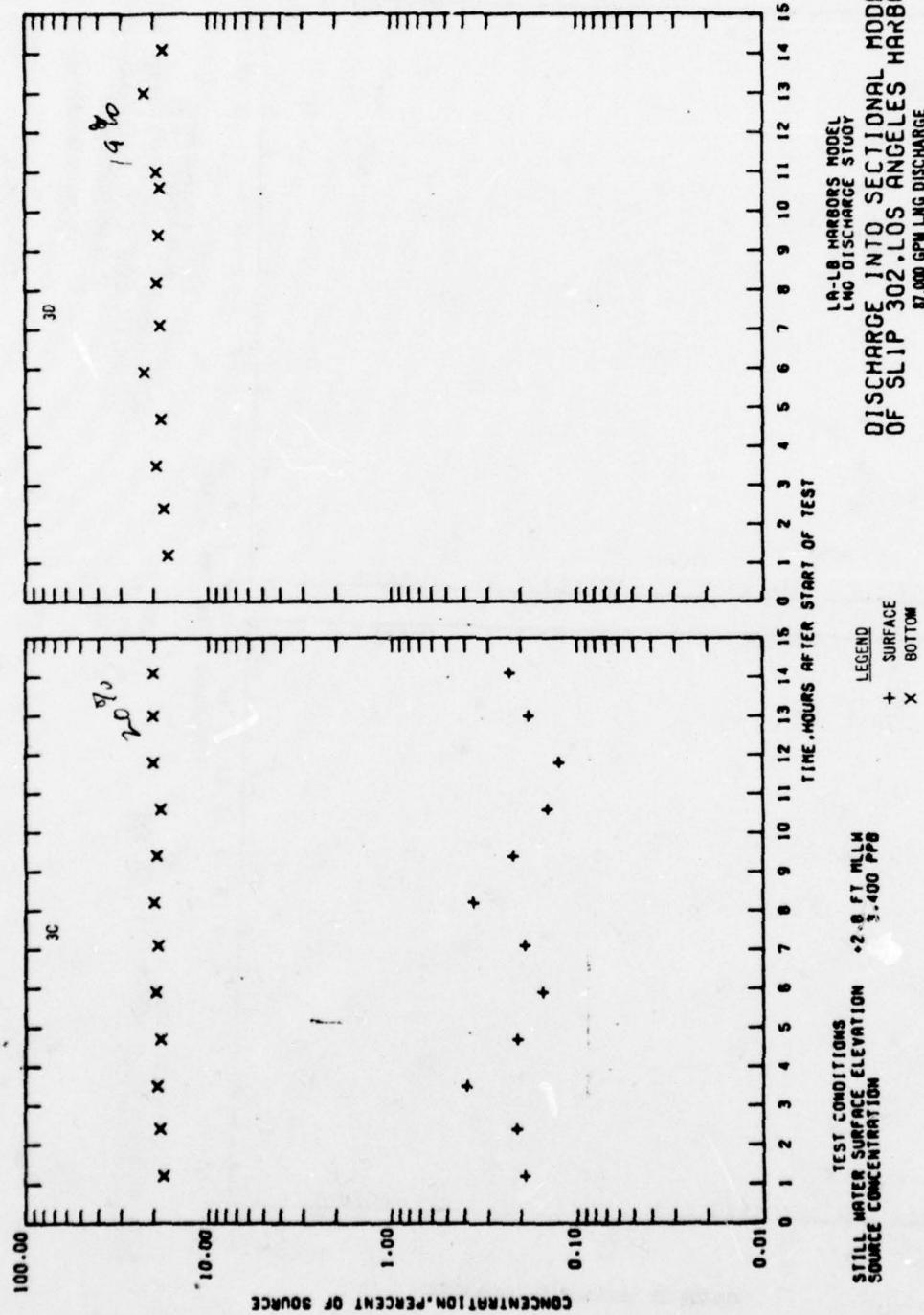
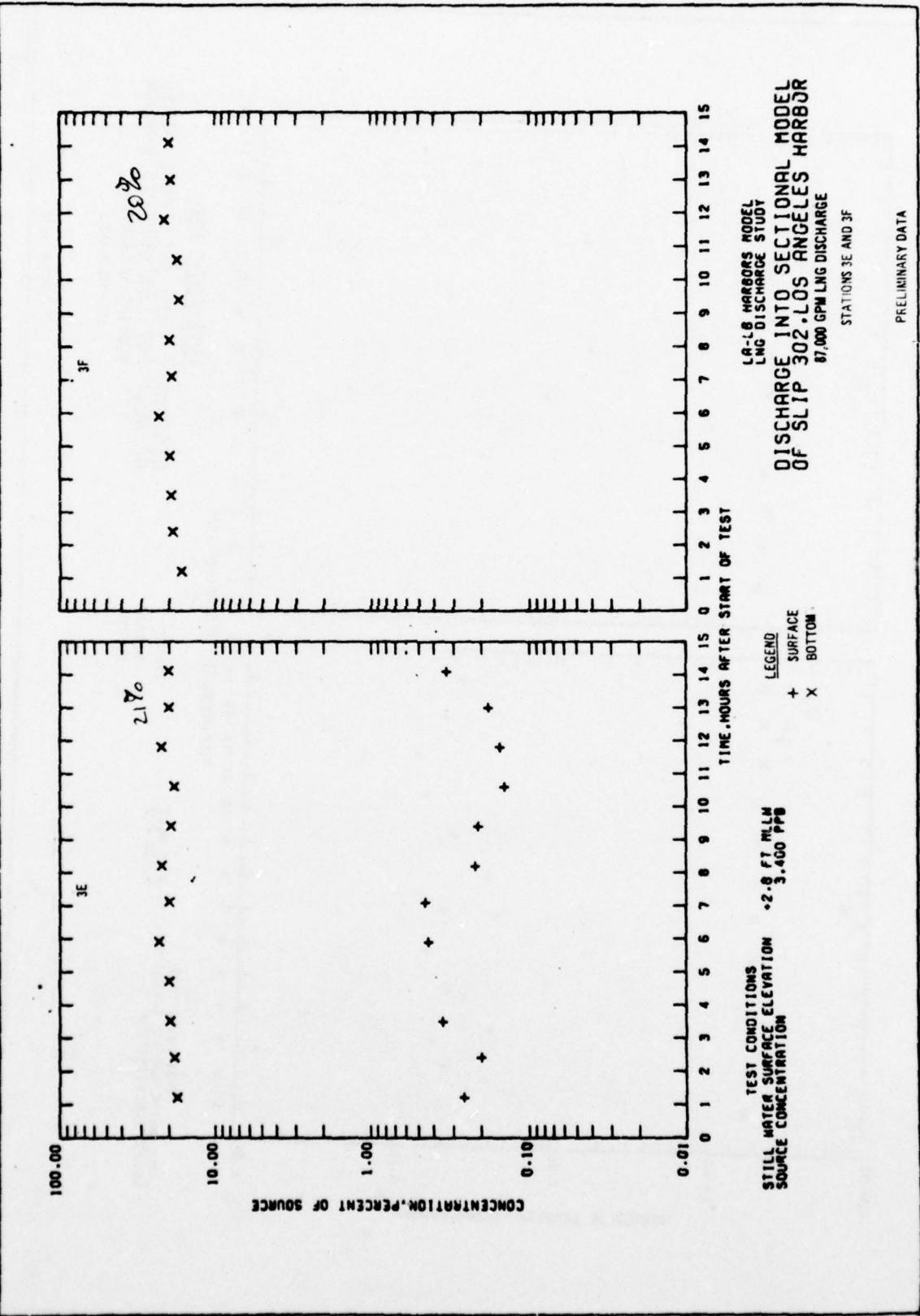
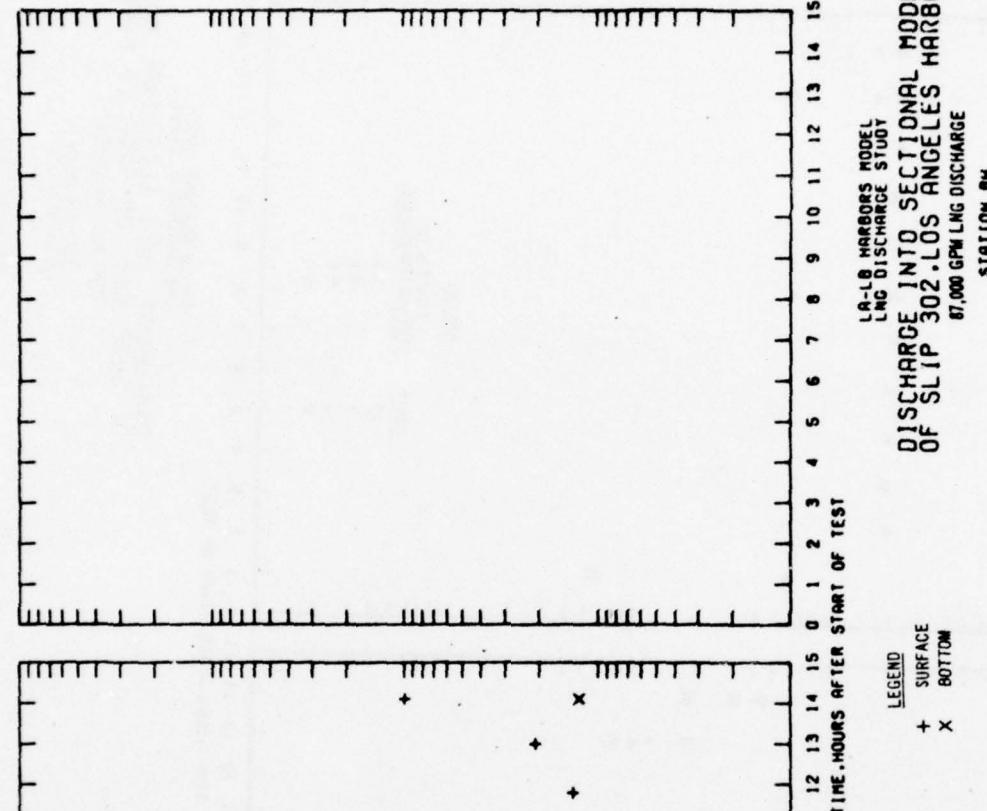
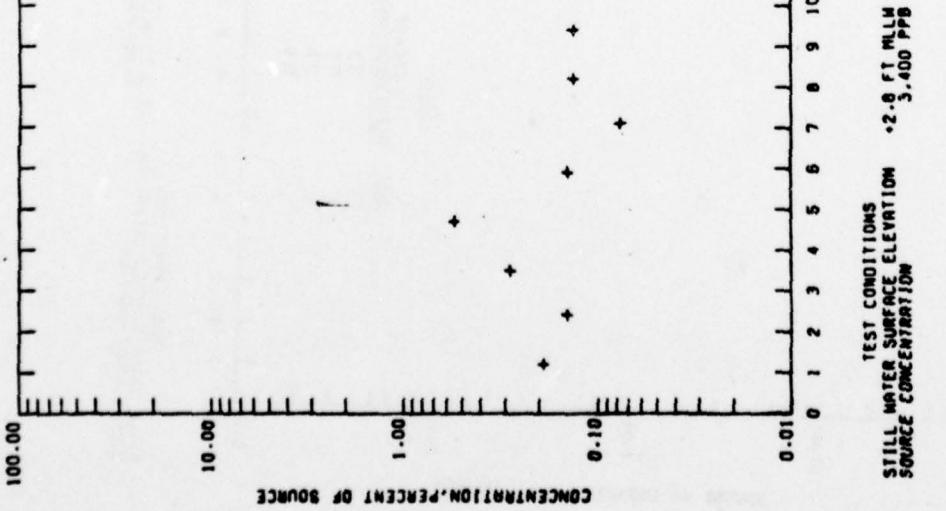
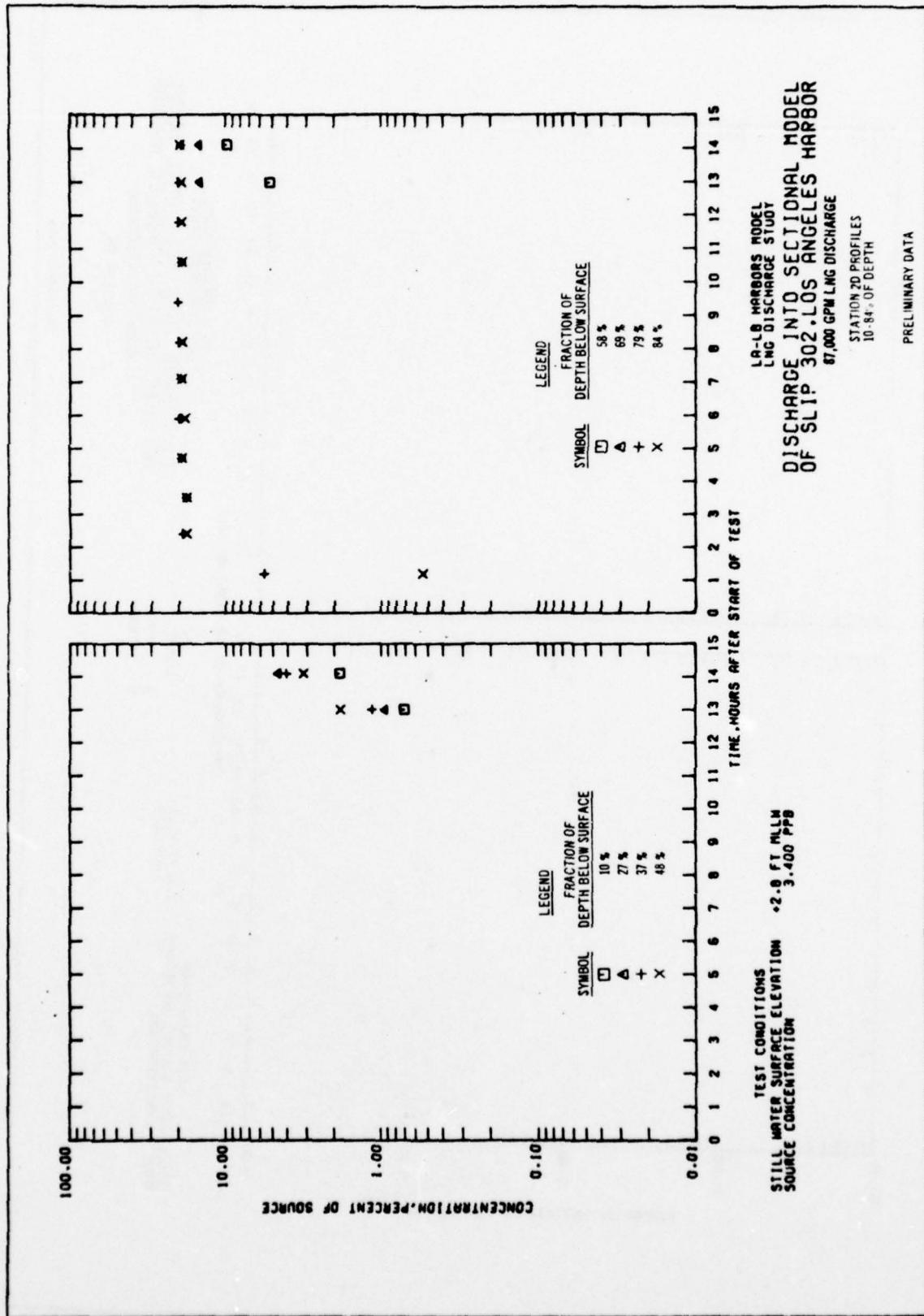
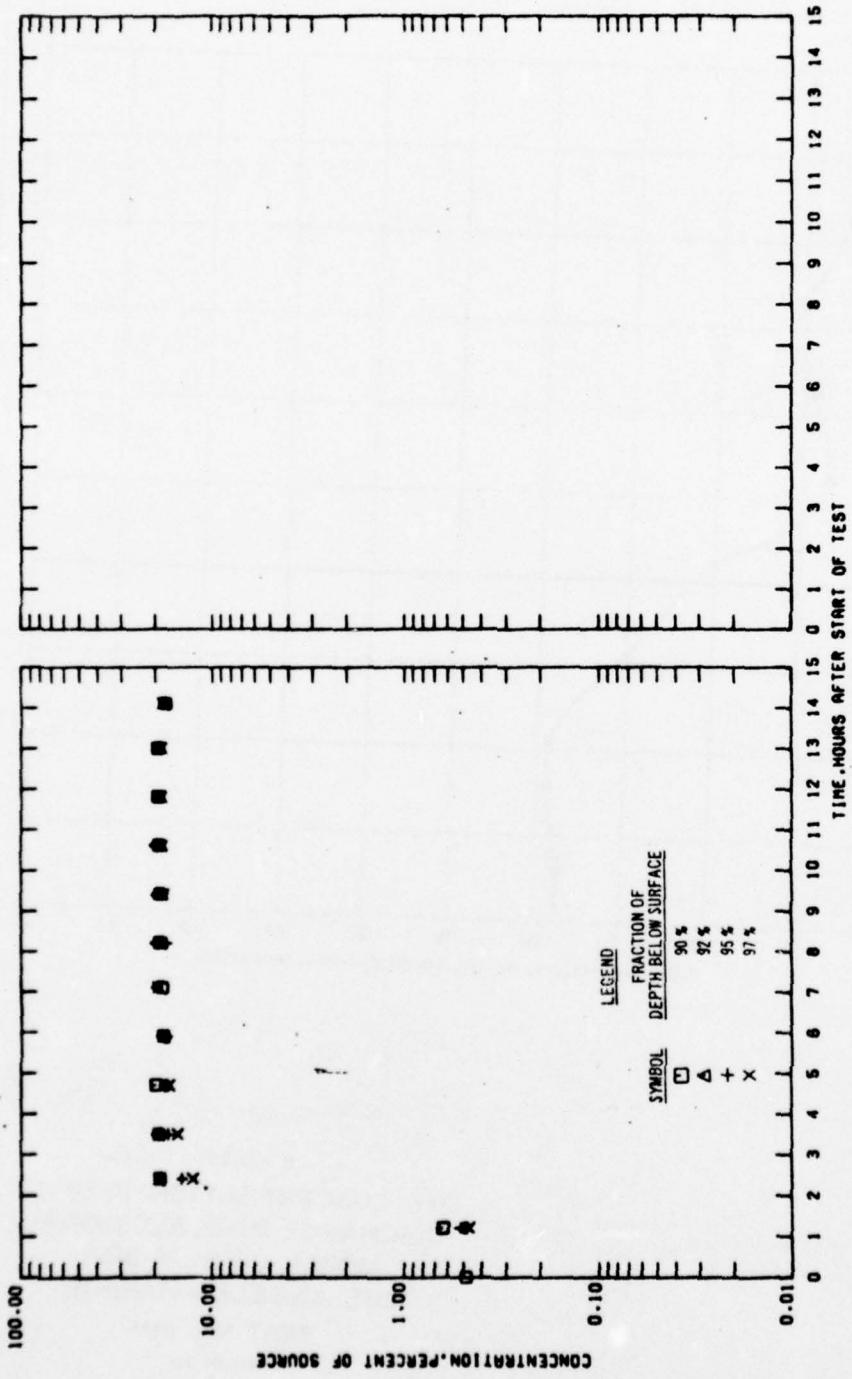


PLATE L3
PRELIMINARY DATA









LA-LB HARBOURS MODEL
LNG DISCHARGE STUDY
DISCHARGE INTO SECTIONAL MODEL
OF SLIP 302, LOS ANGELES HARBOUR

87,000 GPM LNG DISCHARGE
STATION 2D PROFILES
90-97% OF DEPTH

PRELIMINARY DATA

PLATE LG

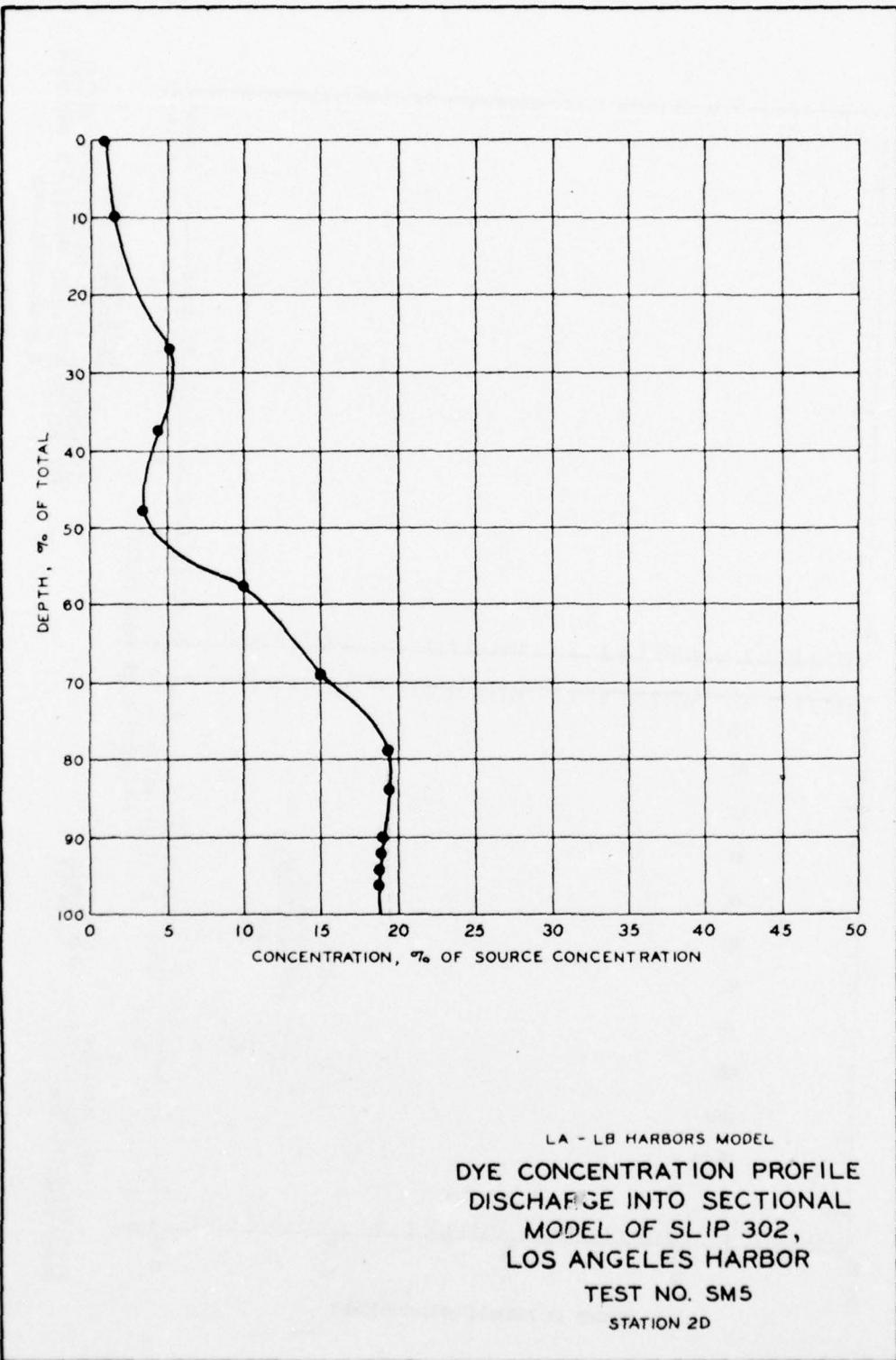
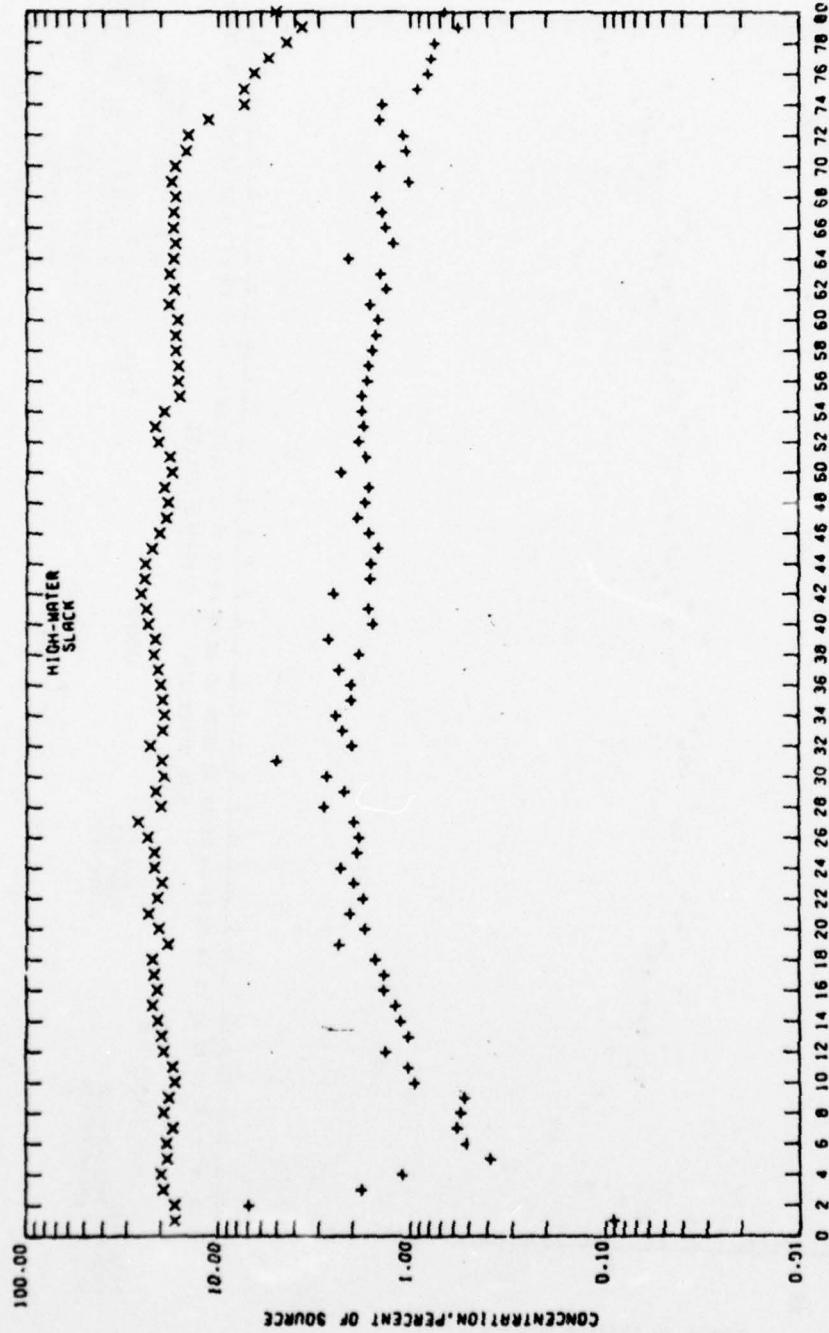


PLATE L9A



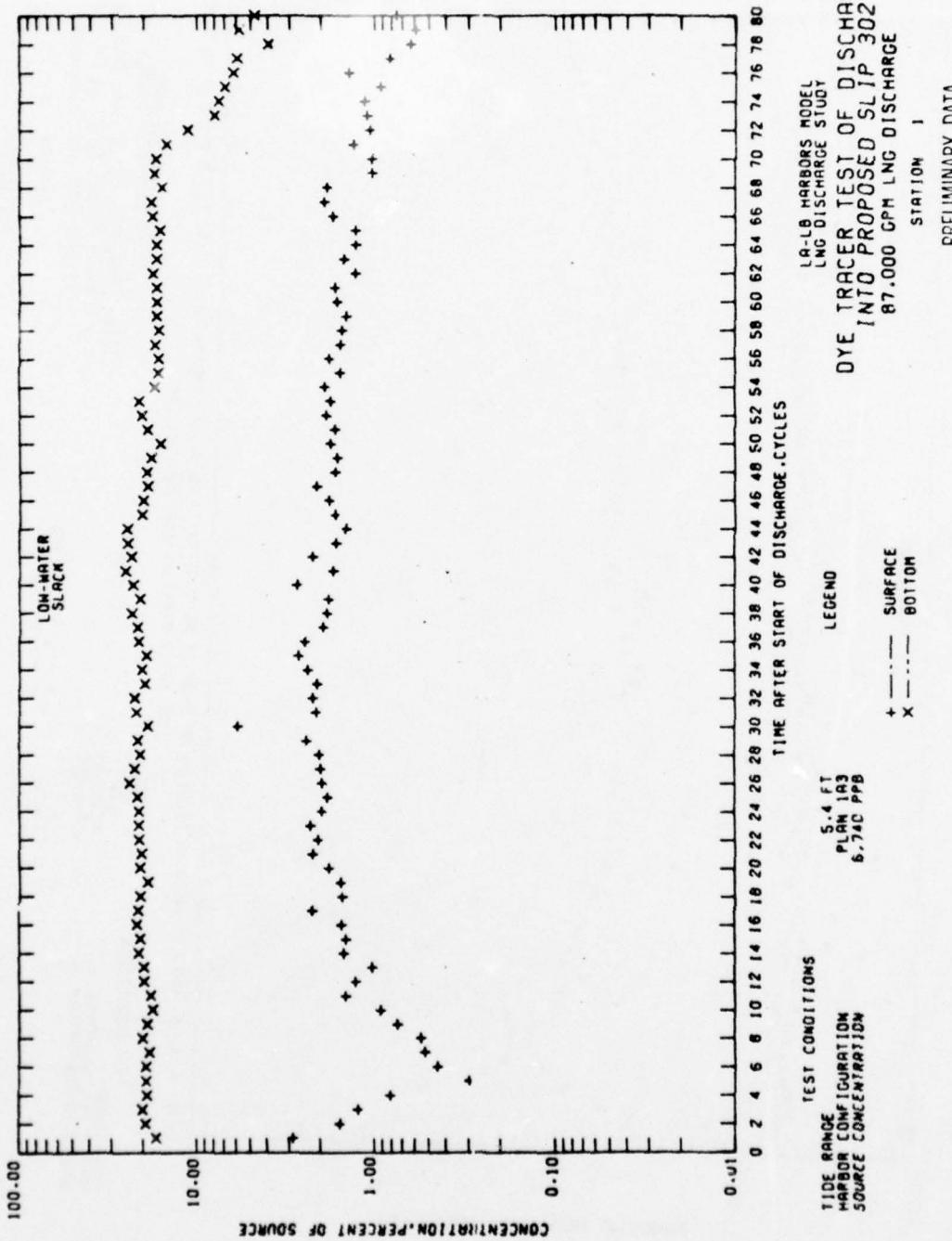
TEST CONDITIONS
 TIDE RANGE 5.4 FT
 HARBOR CONFIGURATION PLAN 163
 SOURCE CONCENTRATION 6.740 PPB

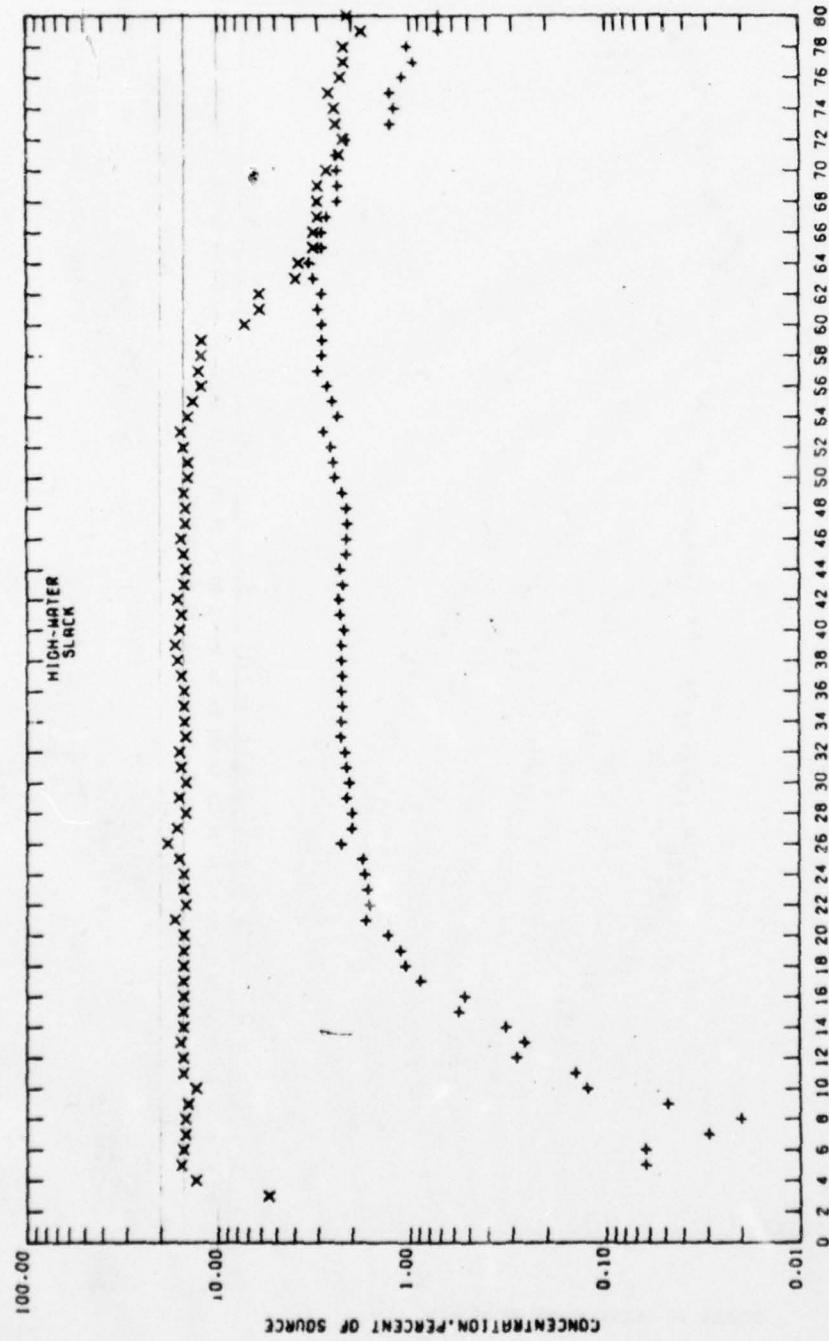
LEGEND
 + — SURFACE
 x — BOTTOM

LA-LG HARBOURS MODEL
 LNG DISCHARGE STUDY
 DYE TRACER TEST OF DISCHARGE
 INTO PROPOSED SLIP 302
 87,000 GPM LNG DISCHARGE
 STATION 1

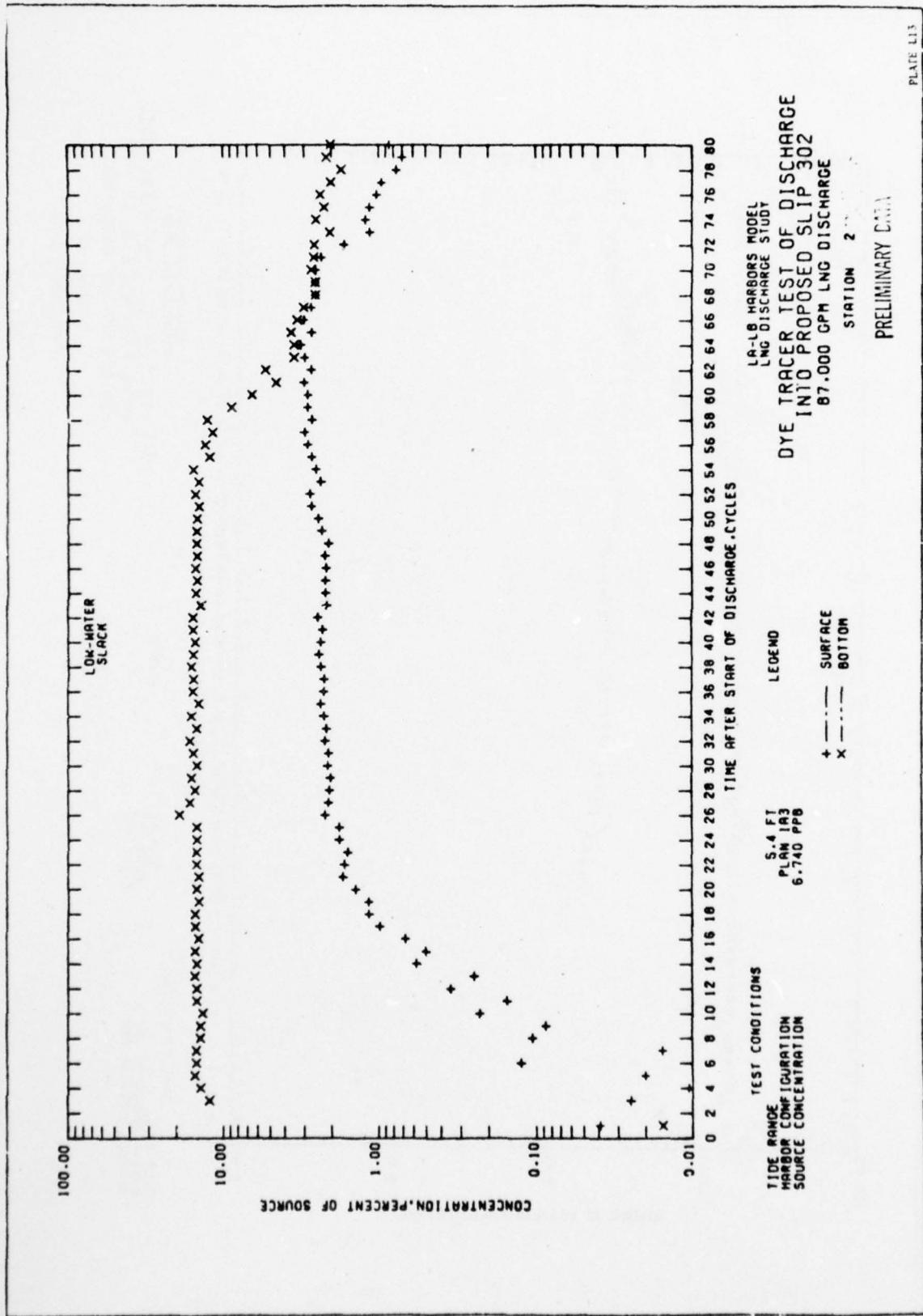
PRELIMINARY DATA

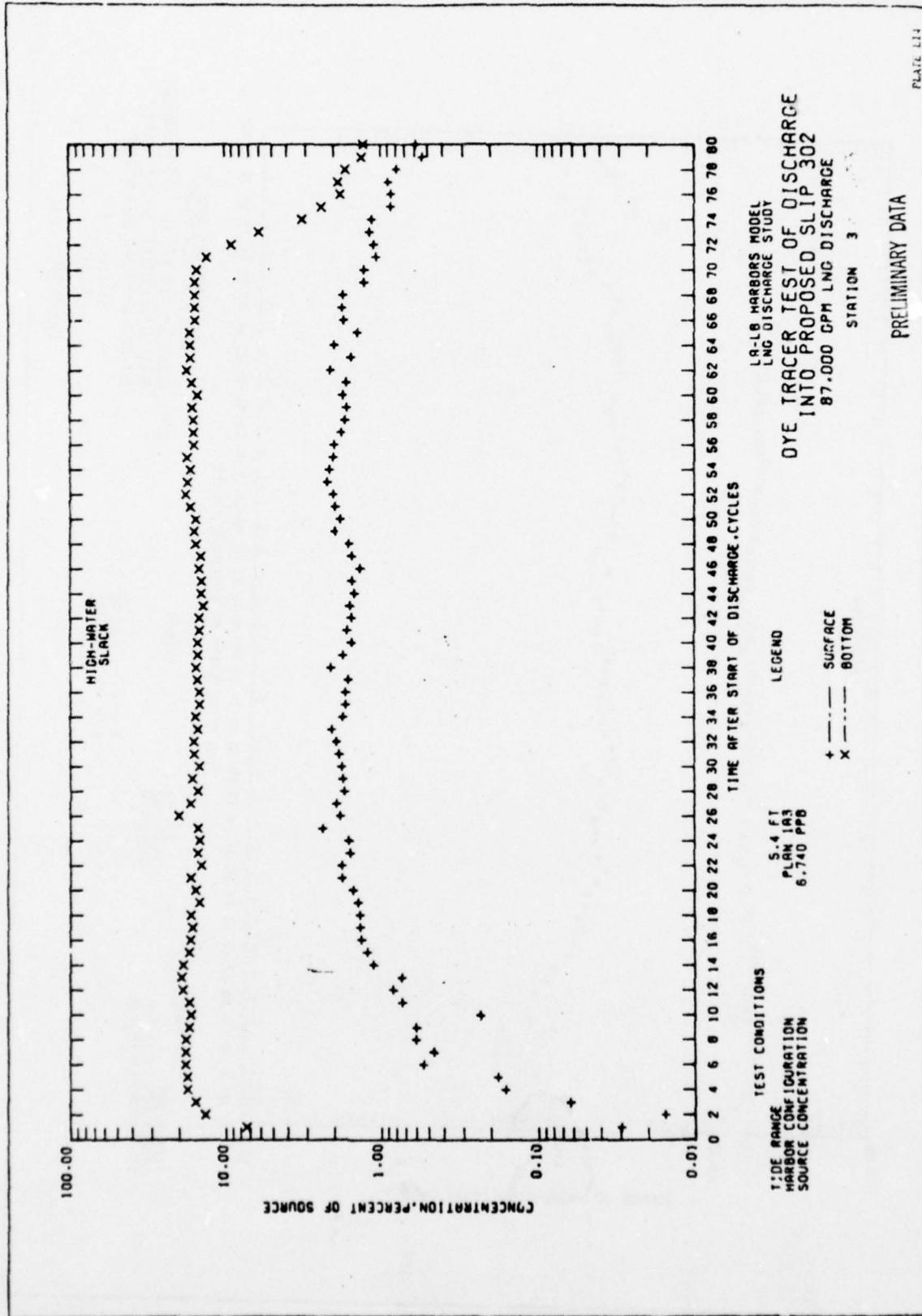
PLATE 11.1

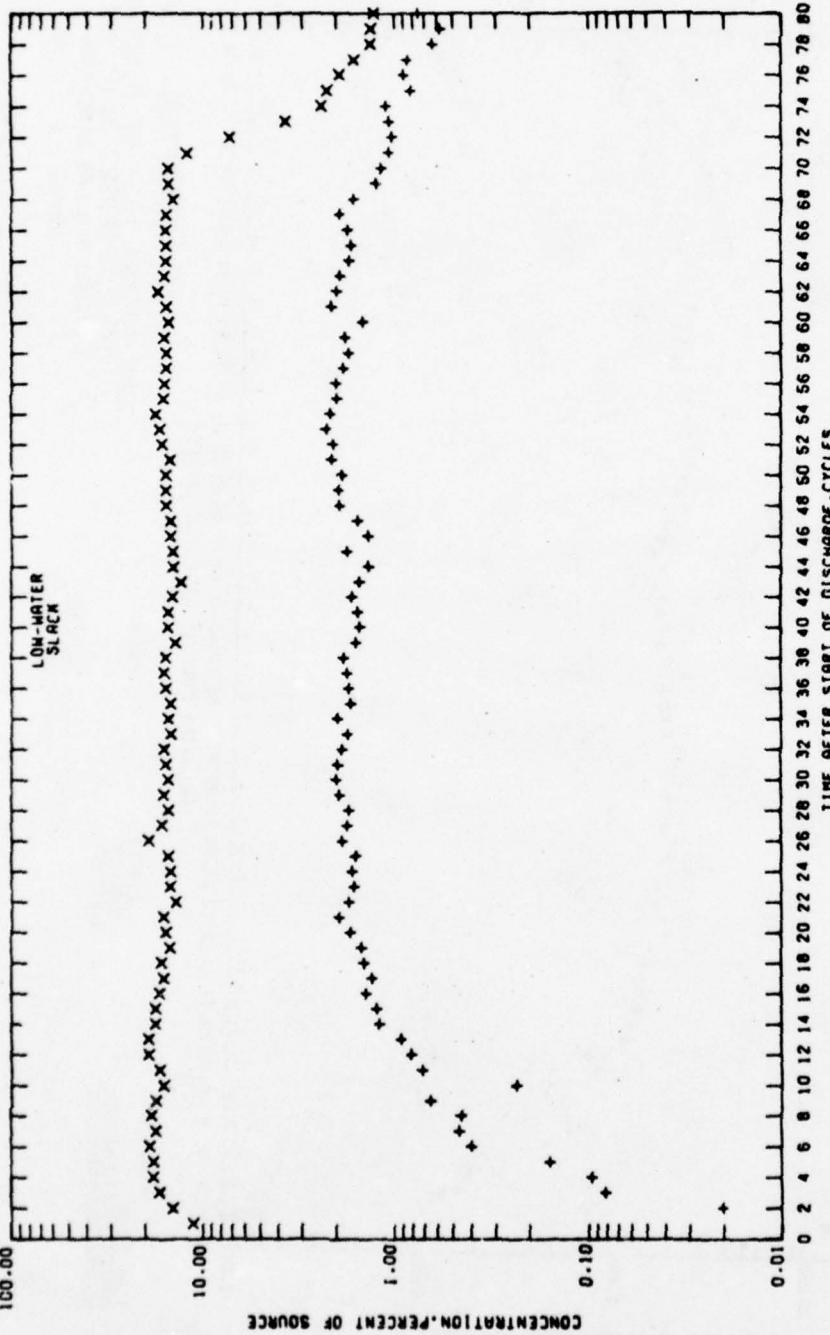




LA-LB HARBOURS MODEL
 LNG DISCHARGE STUDY
 DYE TRACER TEST OF DISCHARGE
 INTO PROPOSED SLIP 302
 87,000 GPM LNG DISCHARGE
 STATION 2
 PRELIMINARY DATA







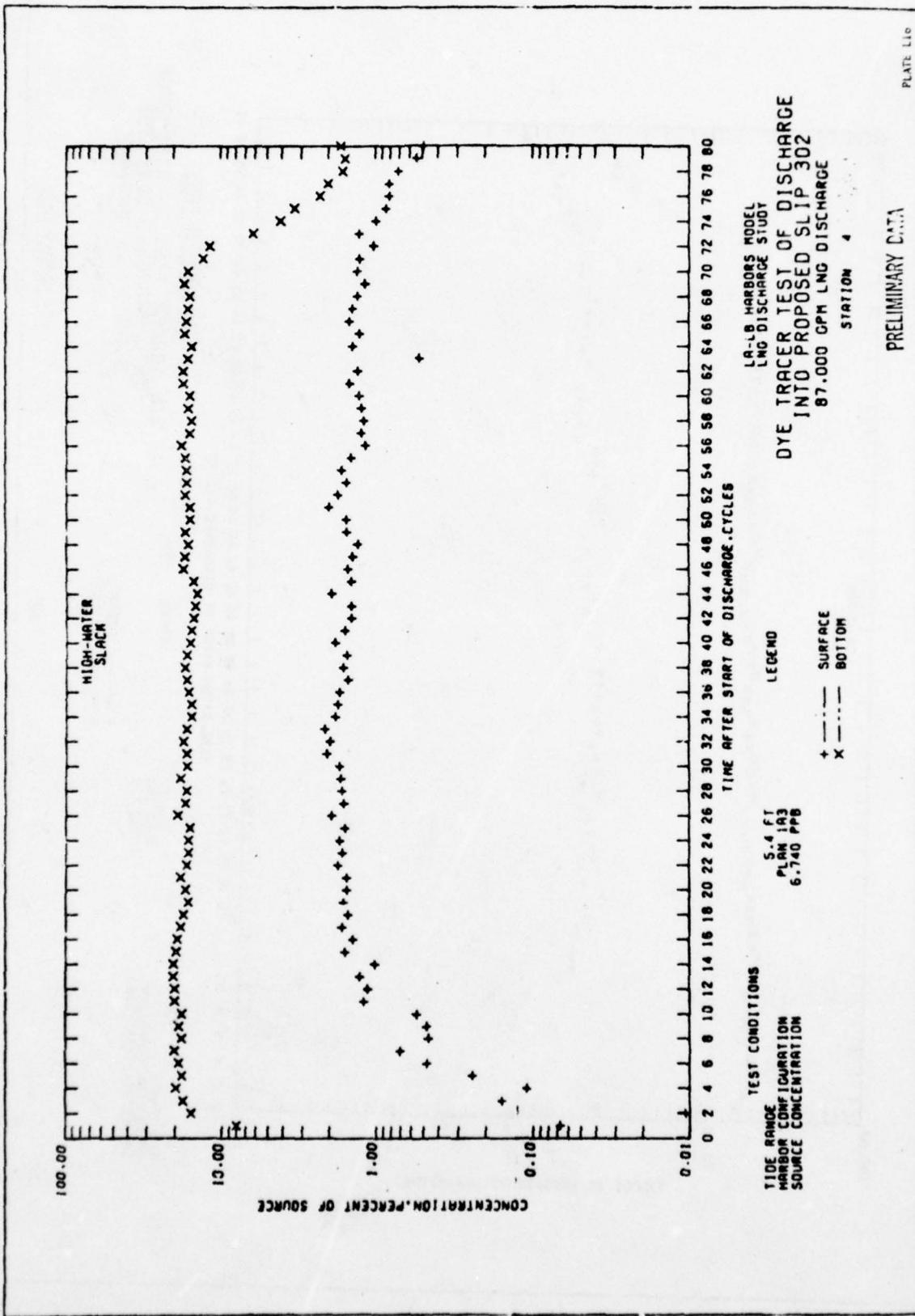
LA-LB HARBOURS MODEL
LNG DISCHARGE STUDY
DYE TRACER TEST OF DISCHARGE
INTO PROPOSED SLIP 302
87,000 GPM LNG DISCHARGE
STATION 3

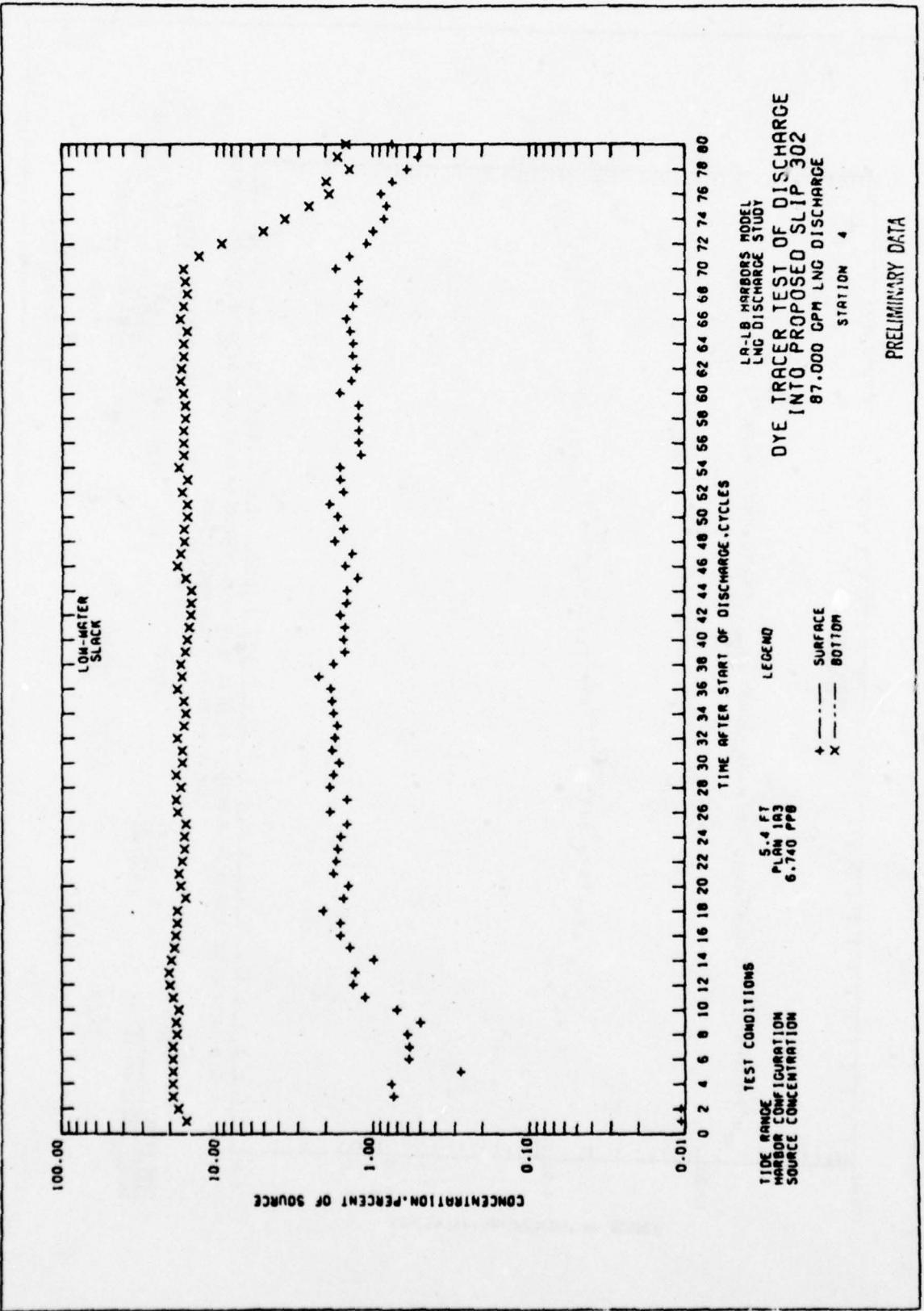
TIDE RANGE TEST CONDITIONS
5.4 FT
PLAN 1A3
6.740 PPB
HARBOR CONFIGURATION
SOURCE CONCENTRATION

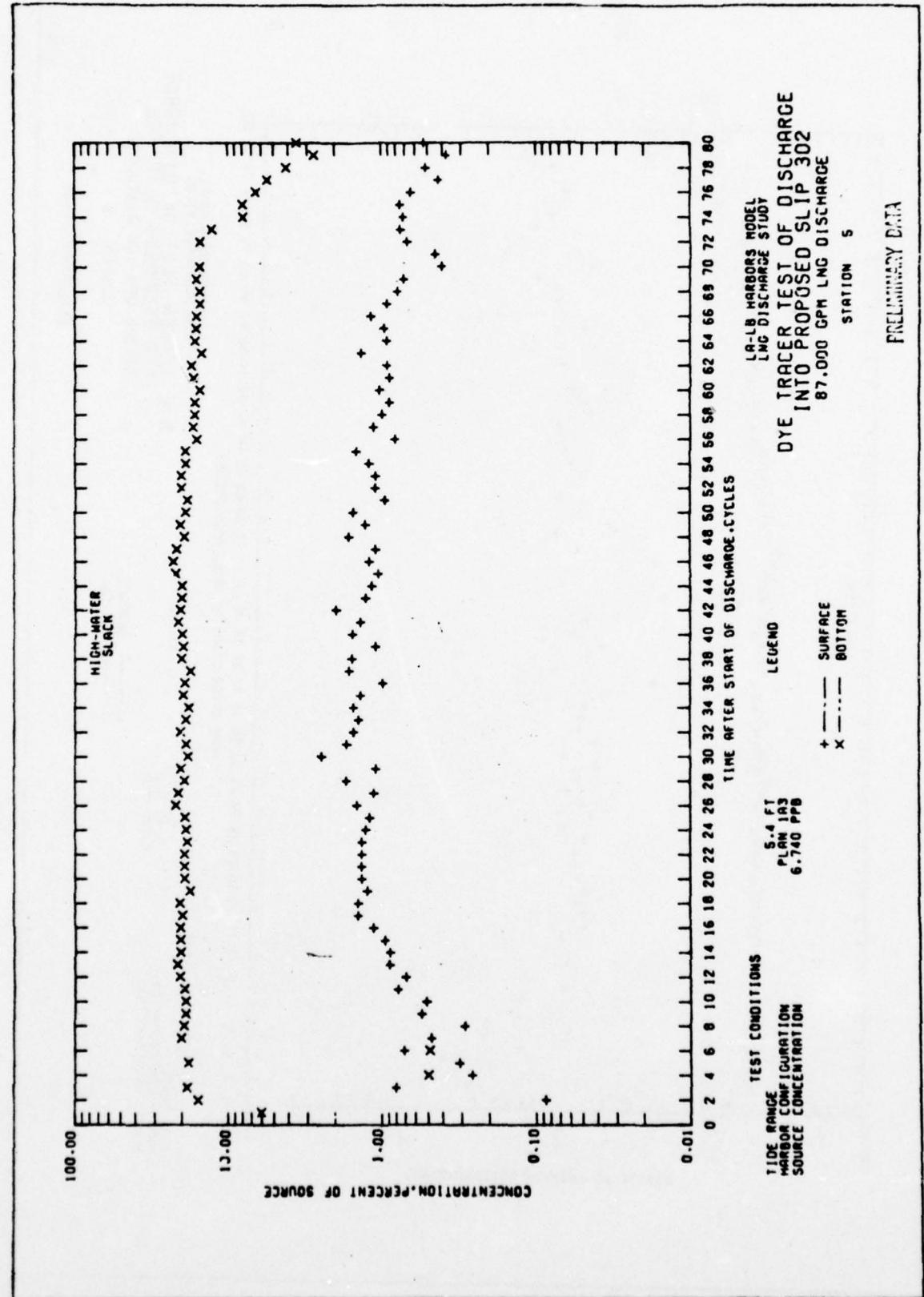
LEGEND
+ - - - SURFACE
x - - - BOTTOM

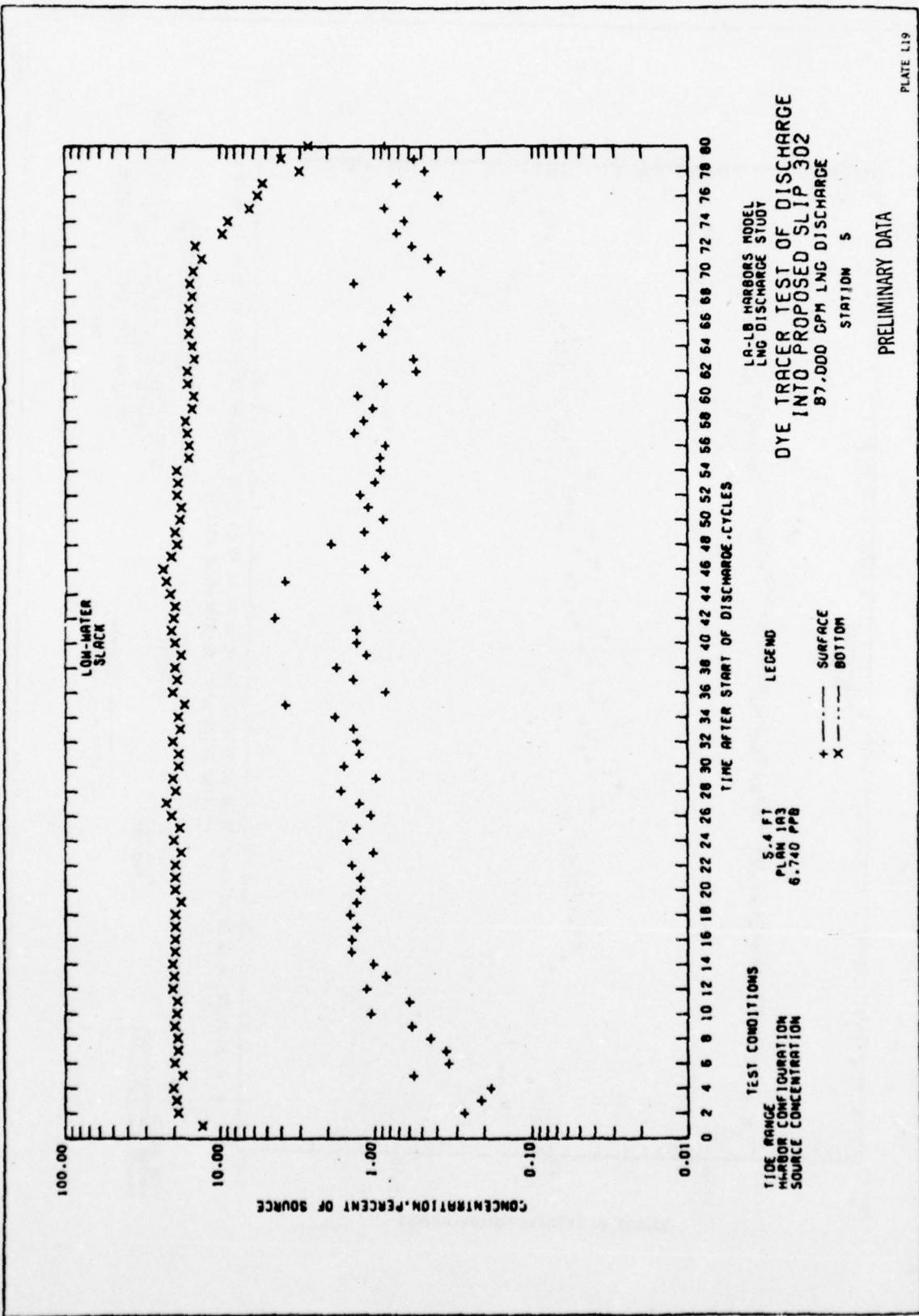
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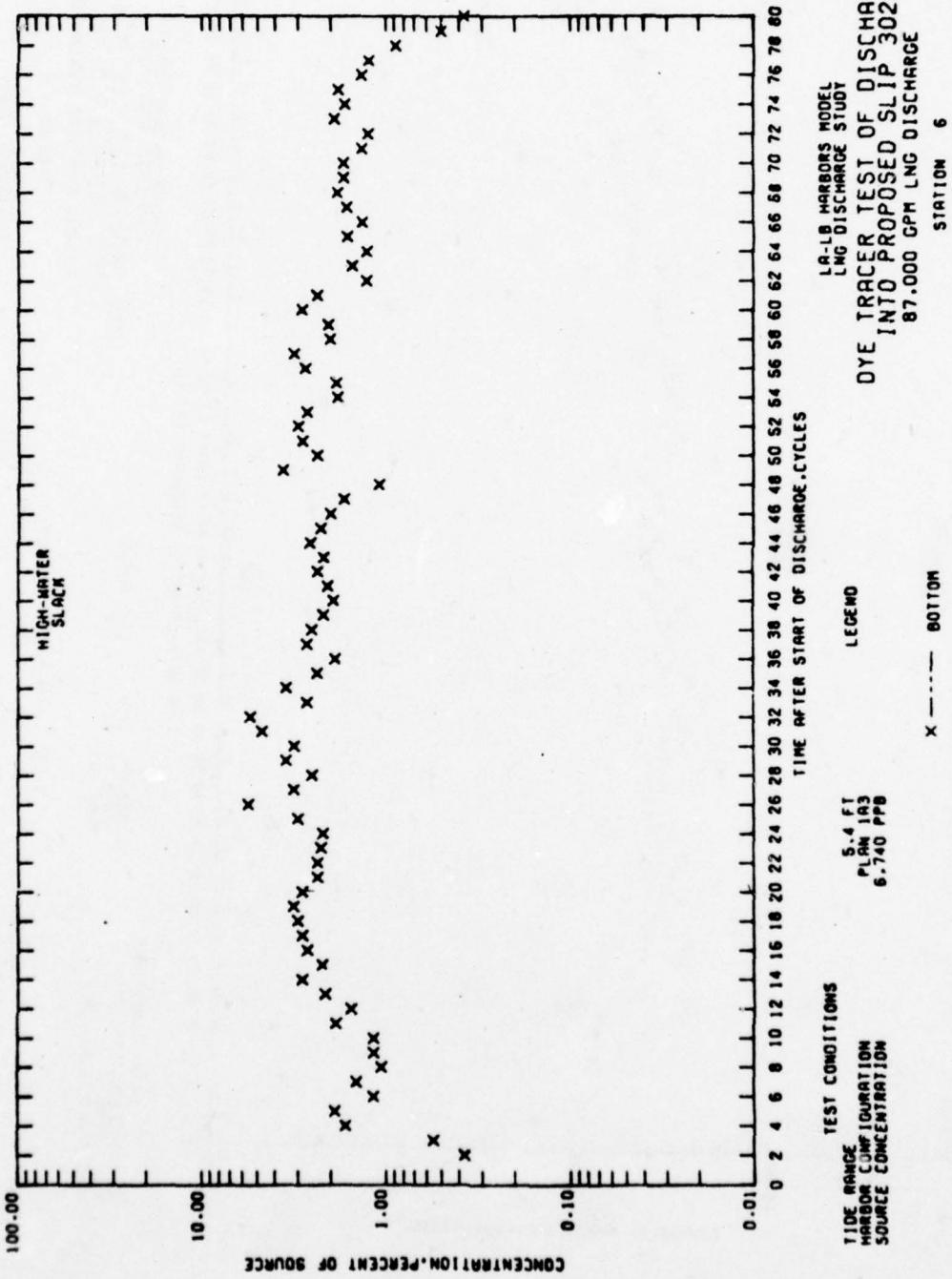
PLATE L15

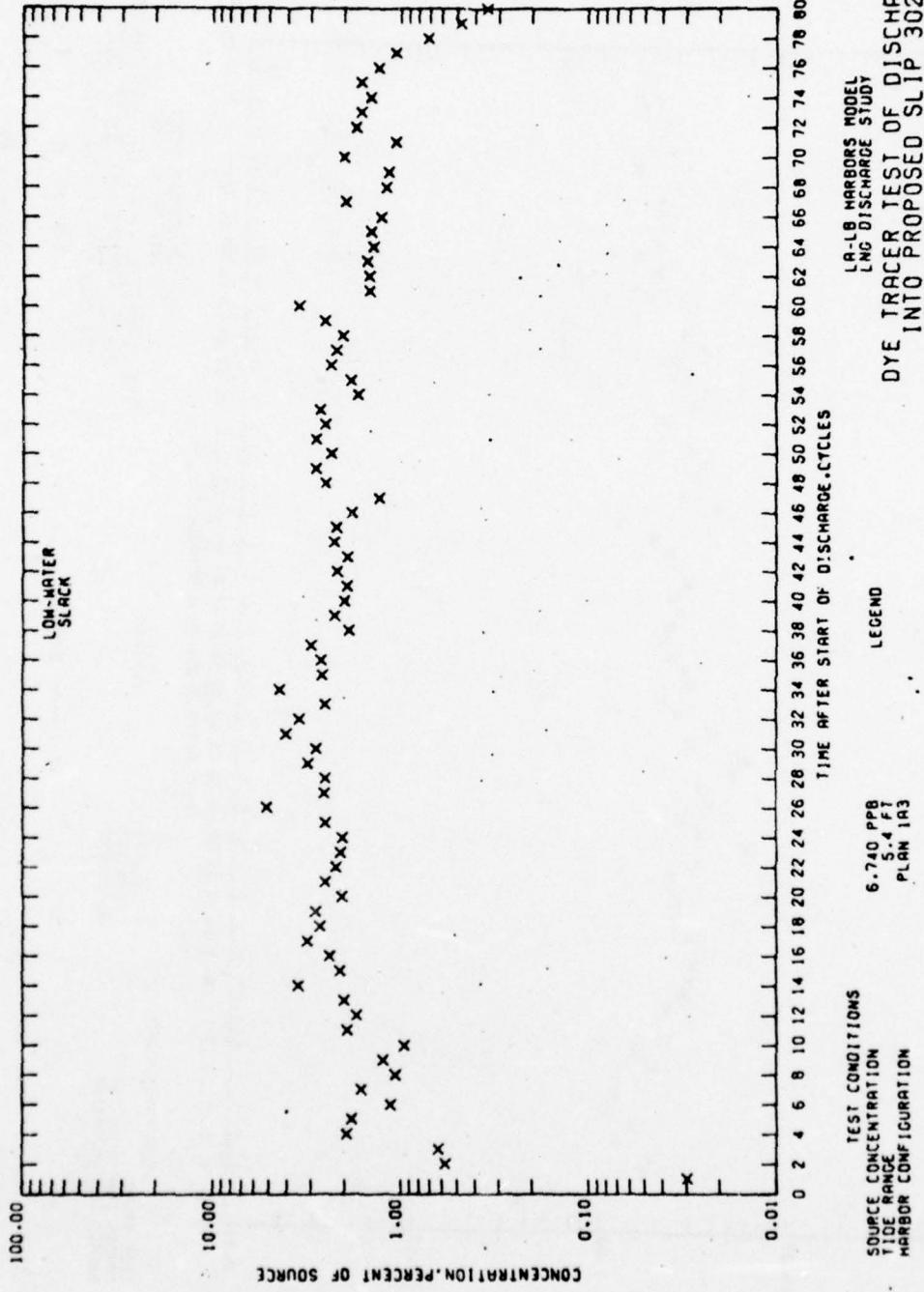


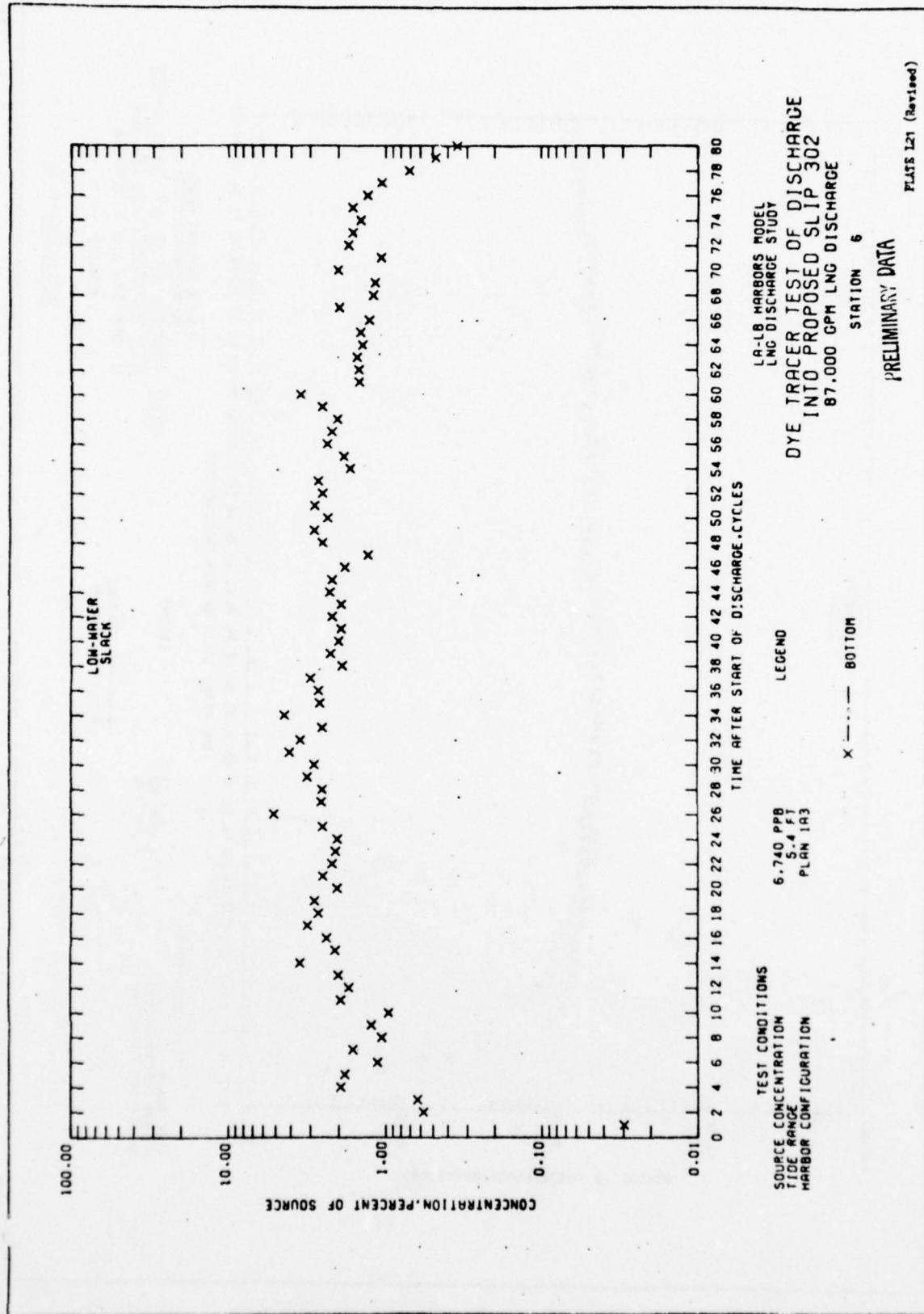












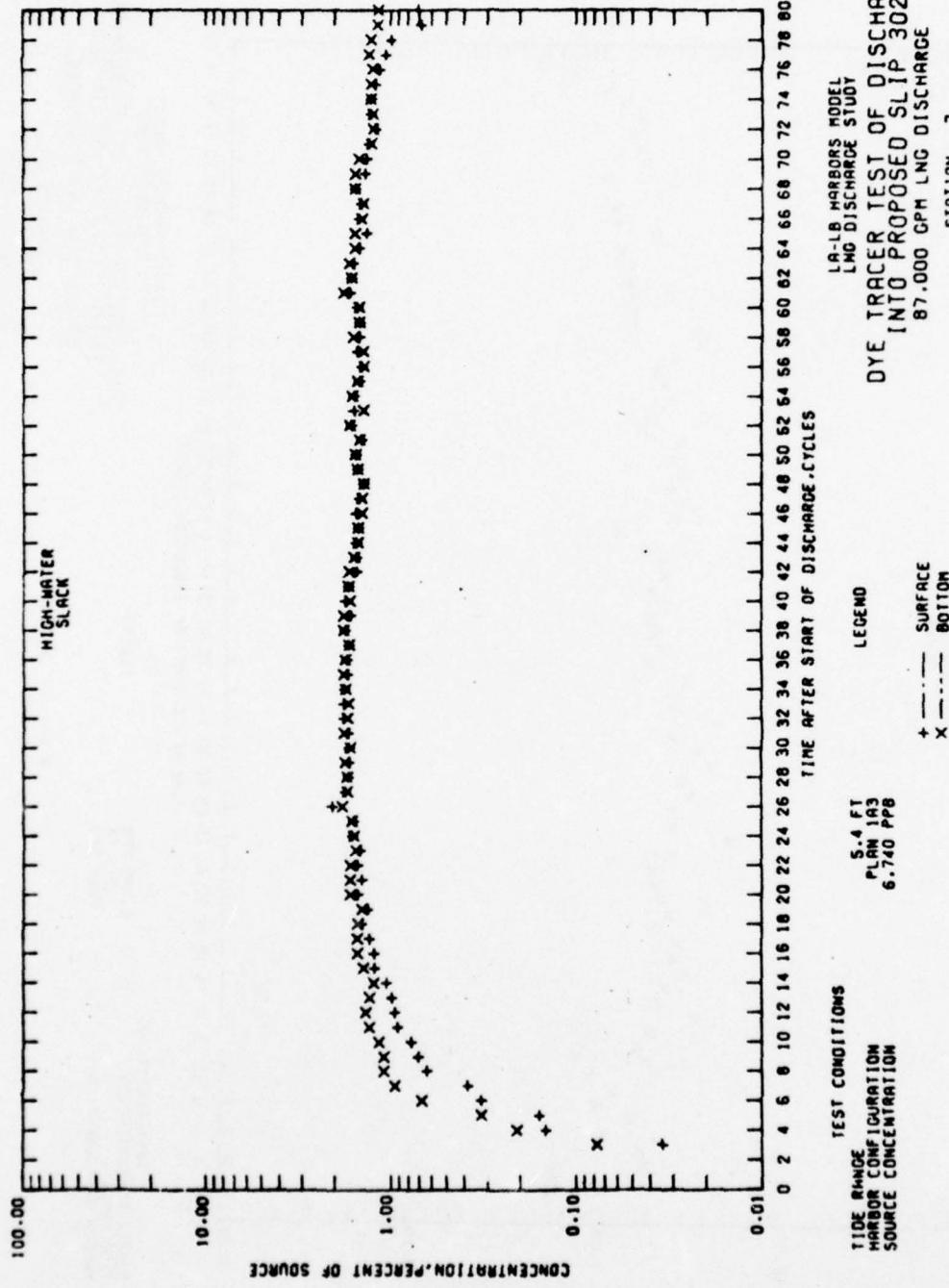
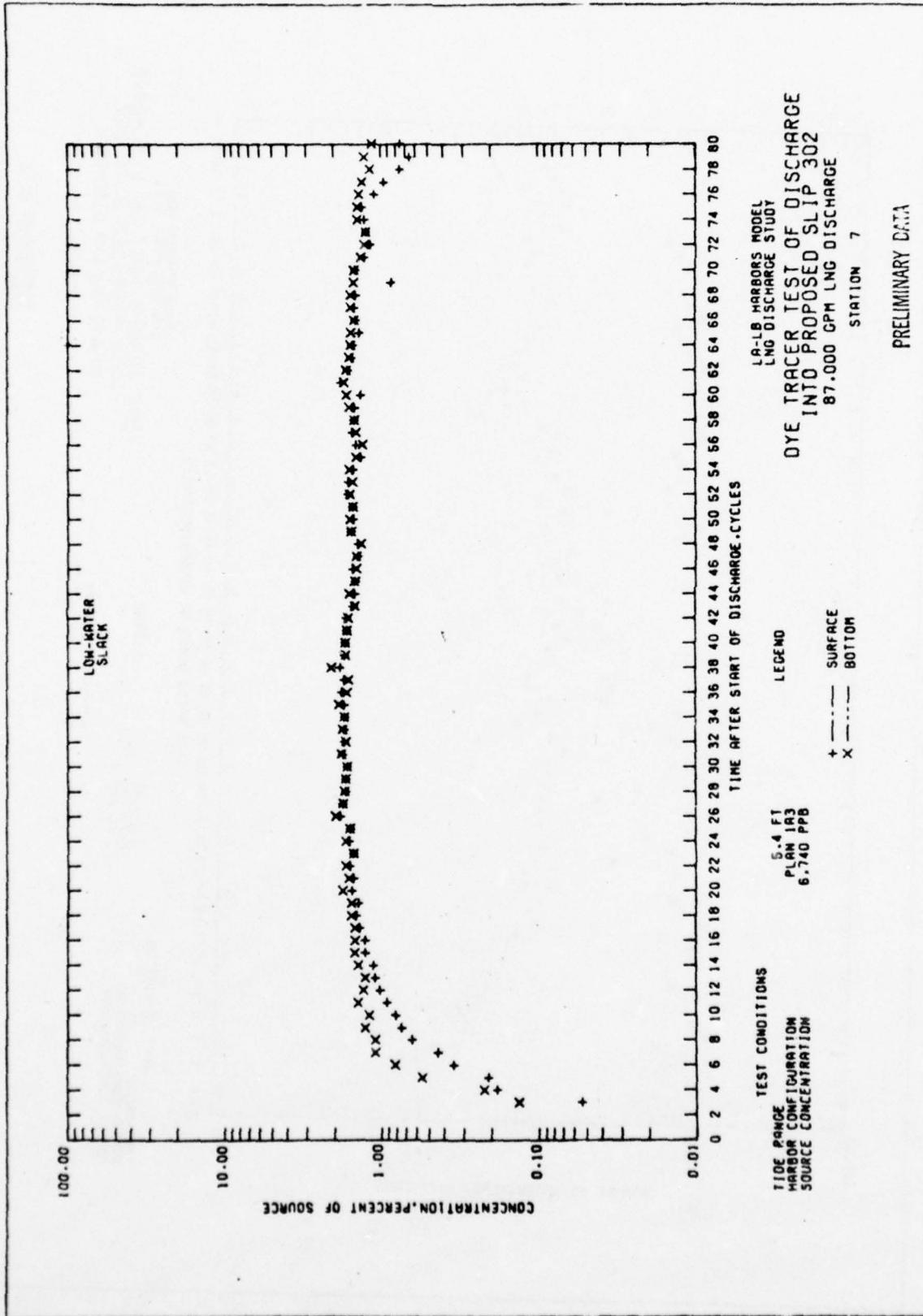
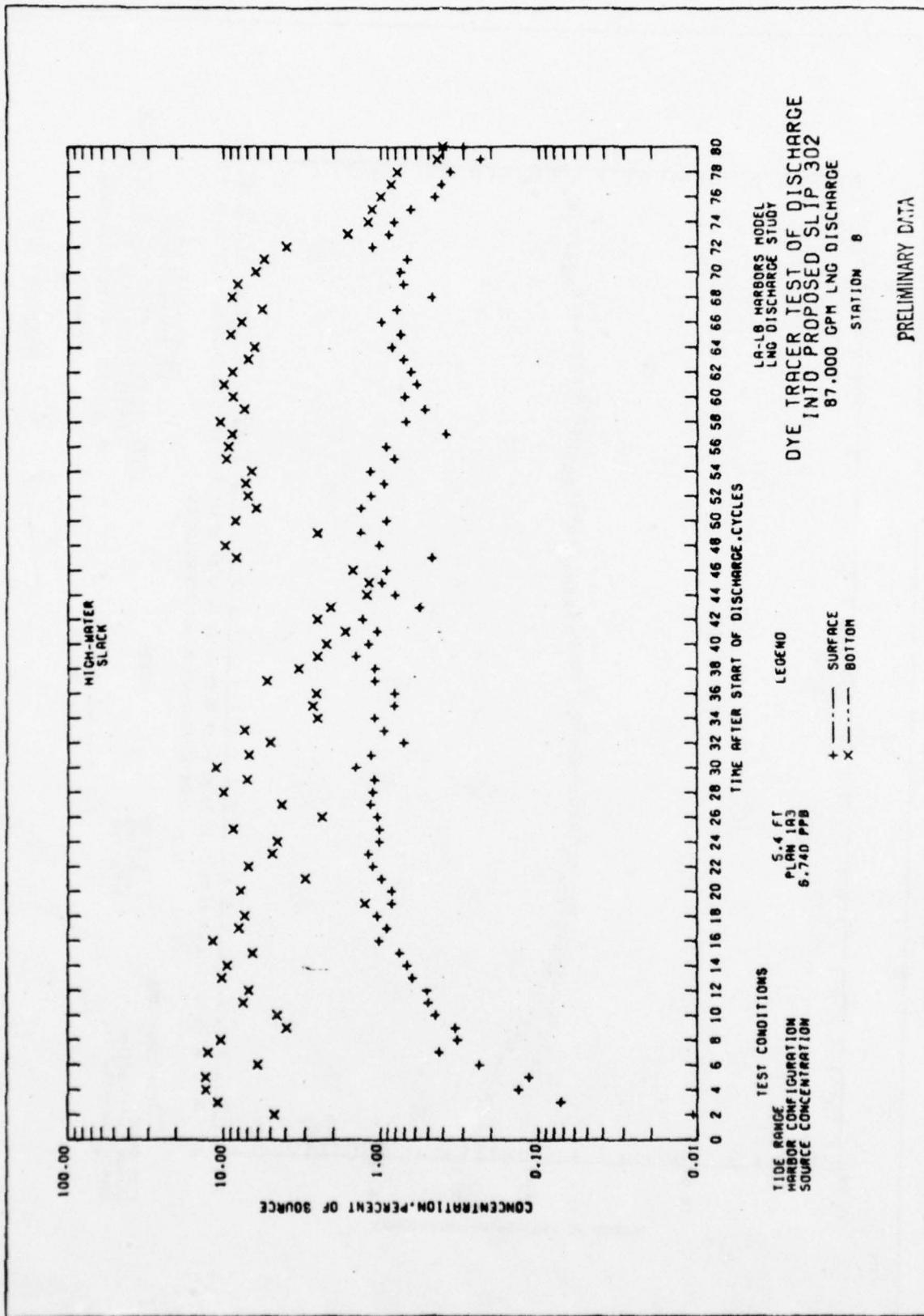
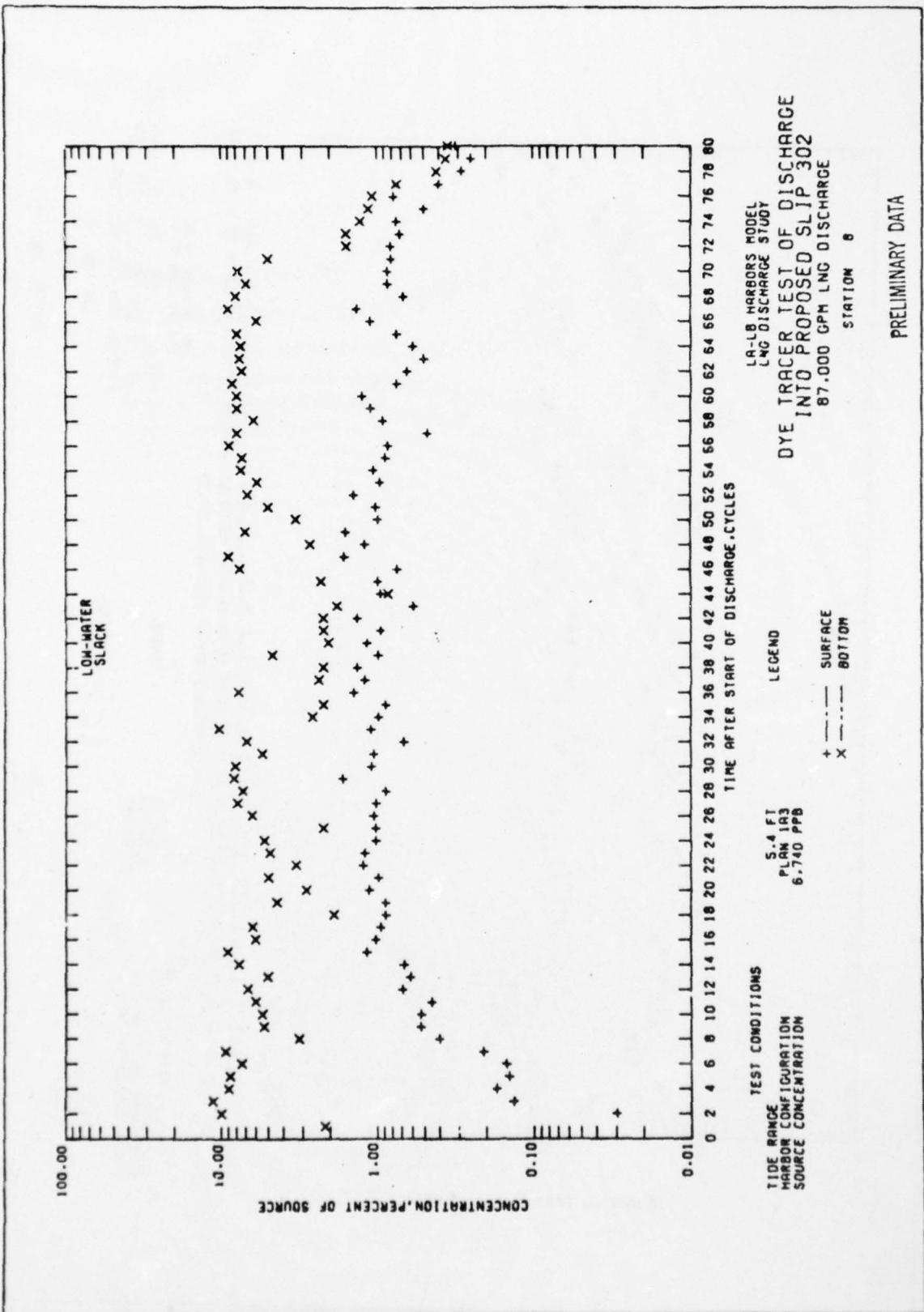
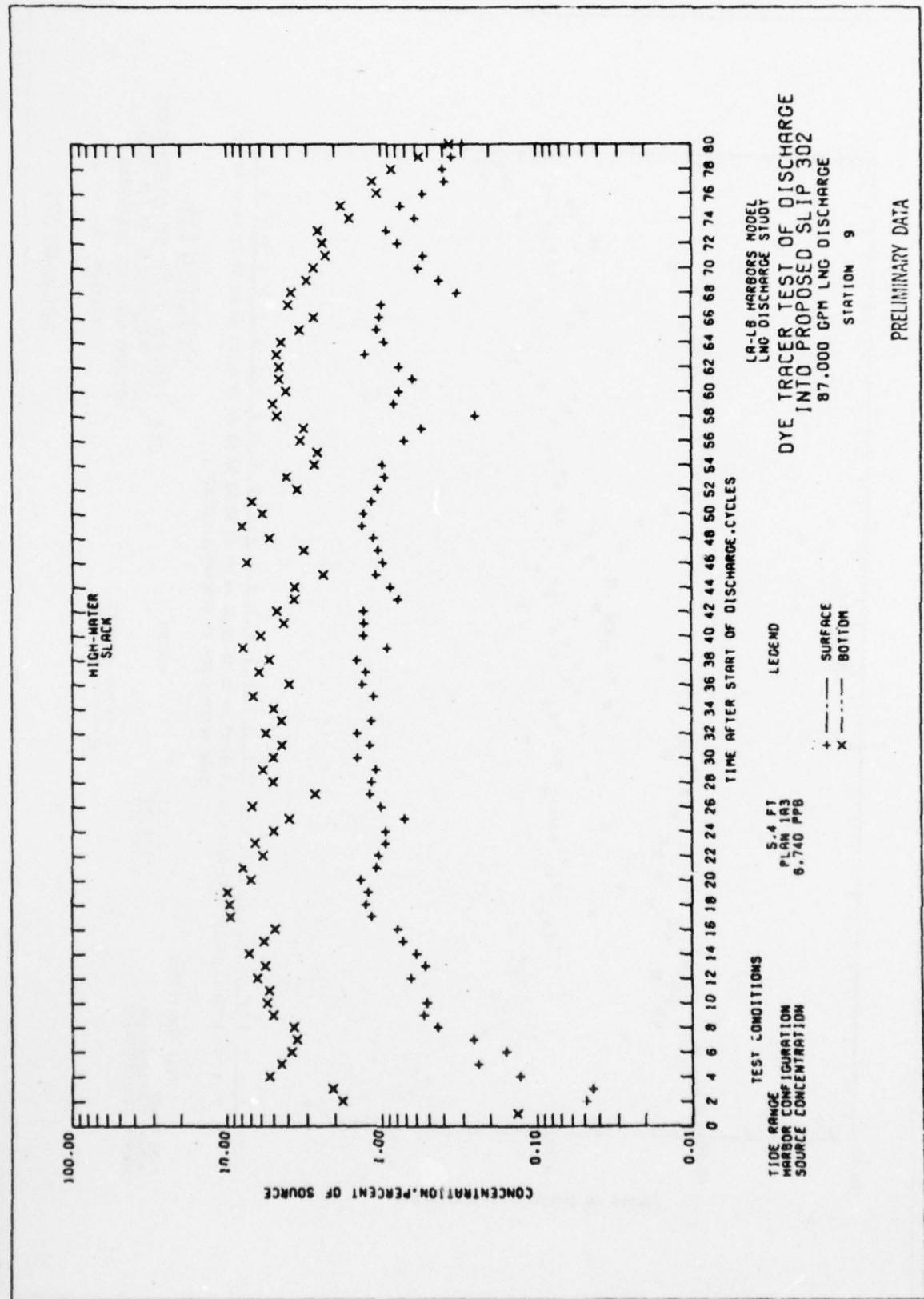


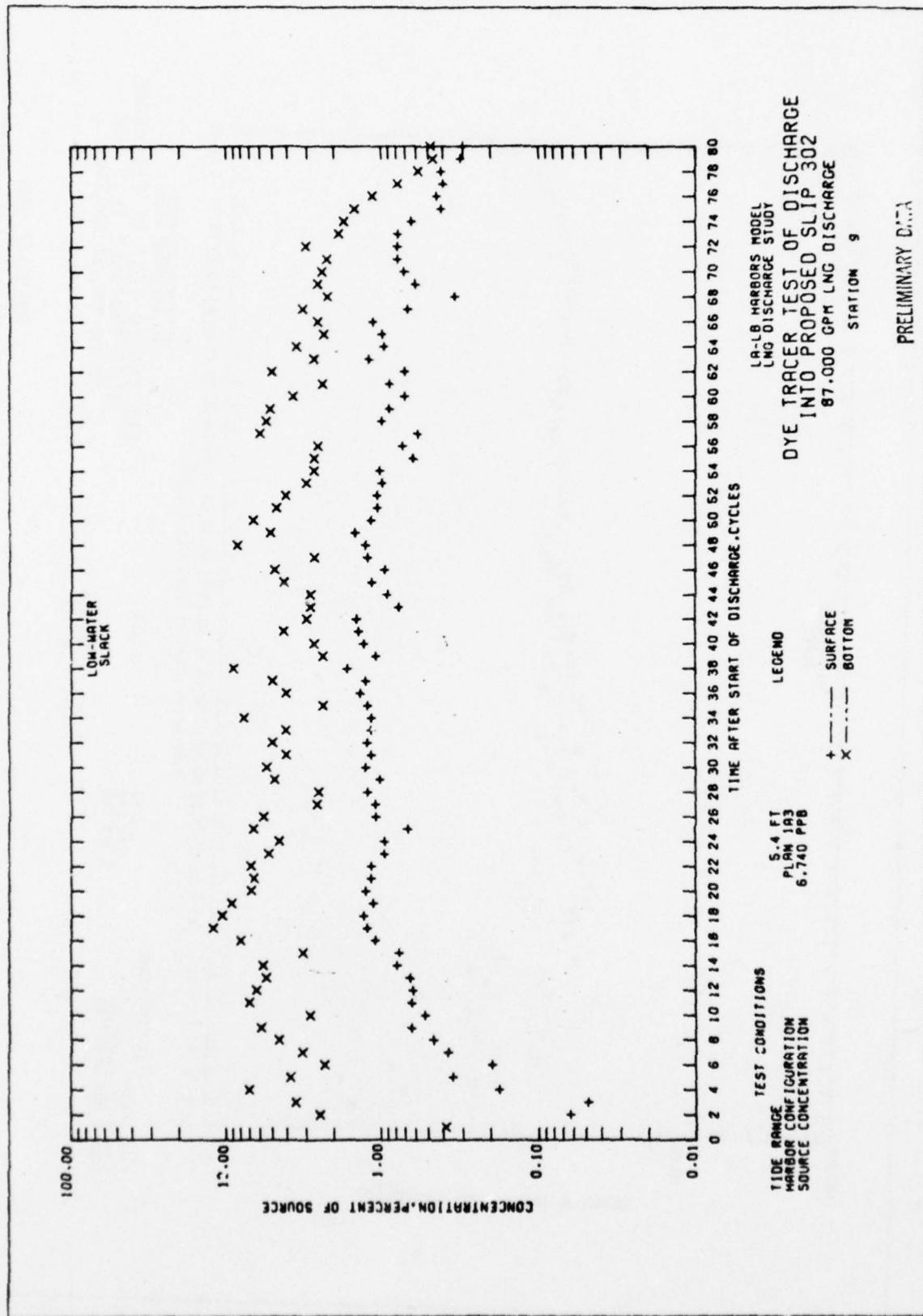
PLATE L-2-2

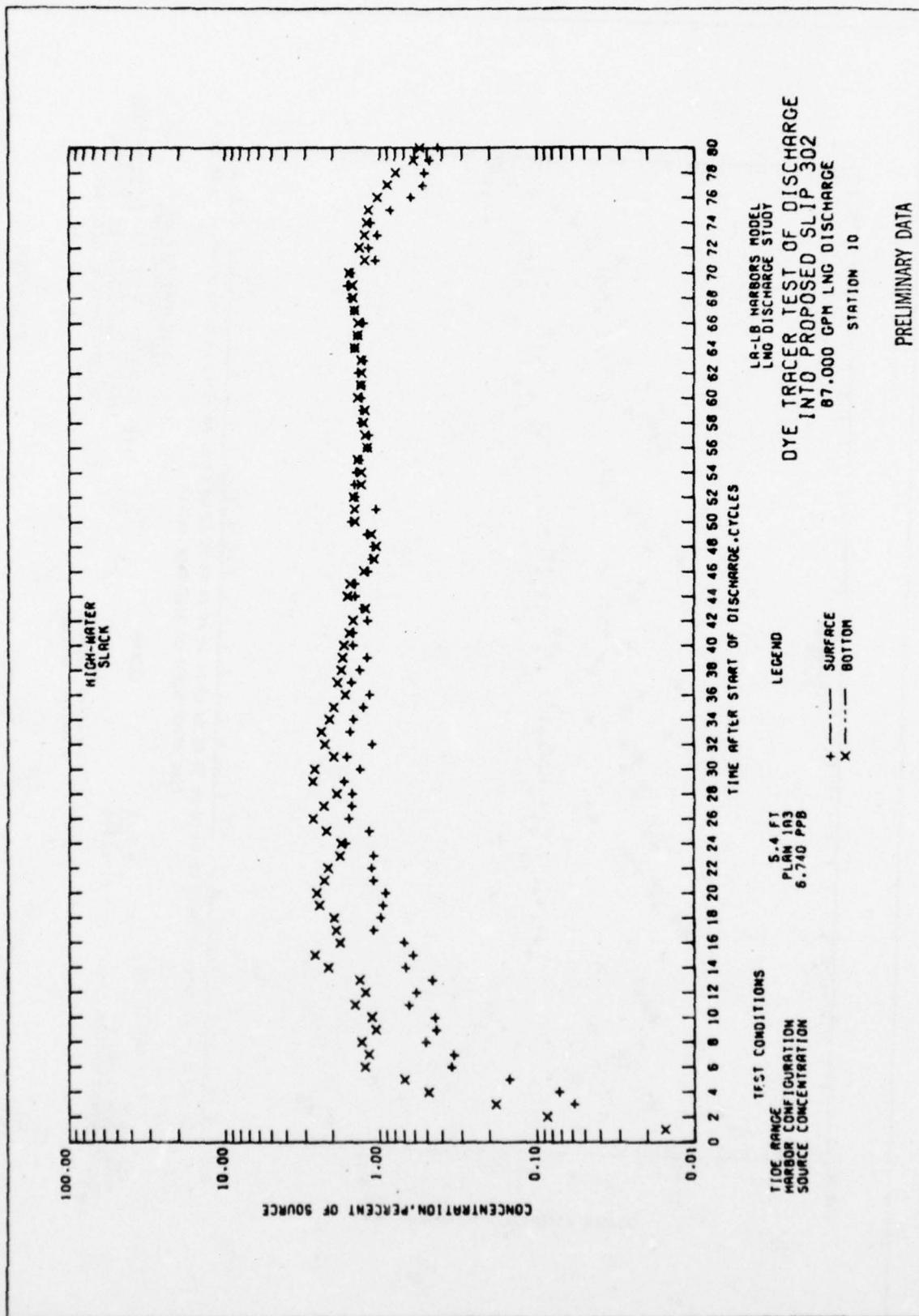


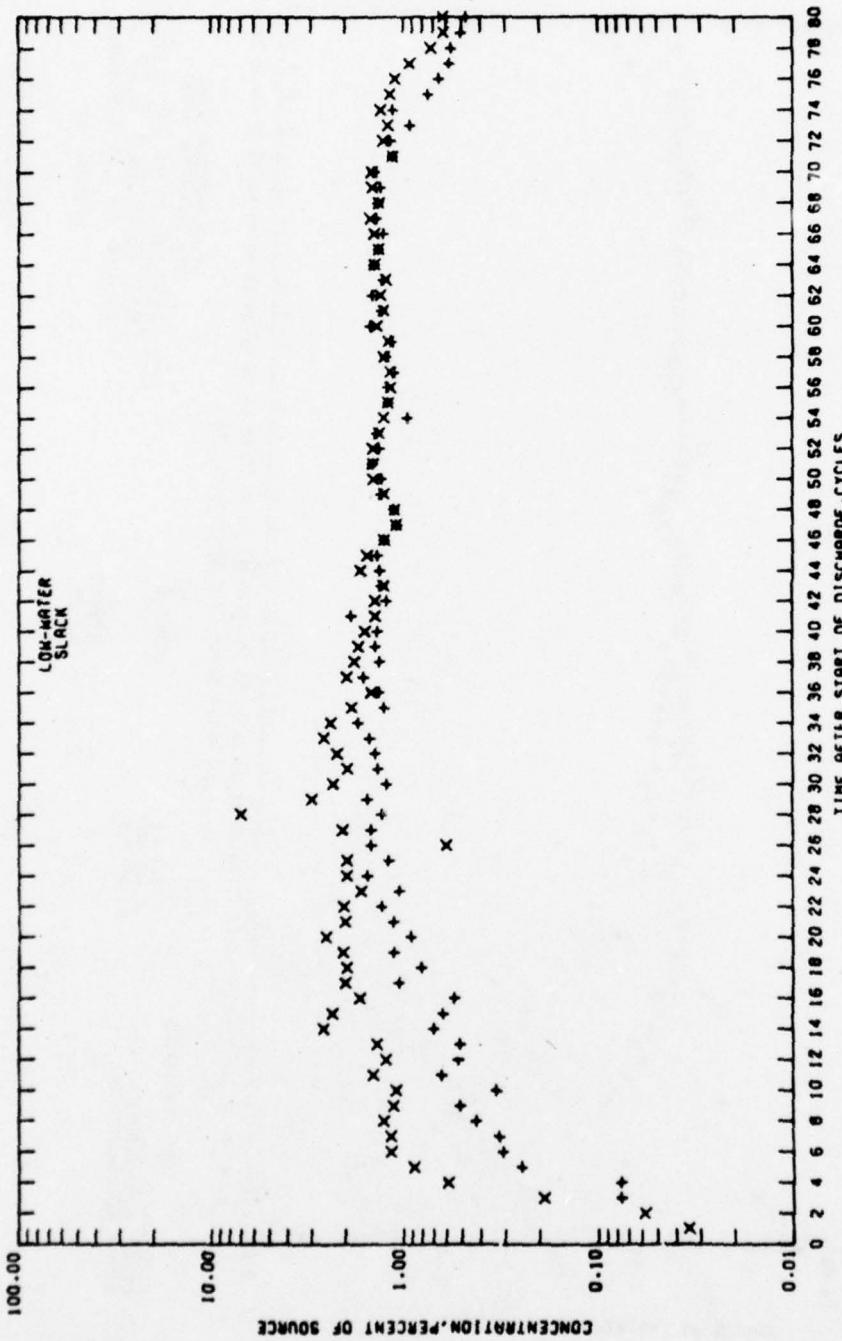












LA-LB HARBORS MODEL
LNG DISCHARGE STUDY
DYE TRACER TEST OF DISCHARGE
INTO PROPOSED SLIP 302
87,000 GPM LNG DISCHARGE
STATION 10

TIDE RANGE
HARBOR CONFIGURATION
SOURCE CONCENTRATION

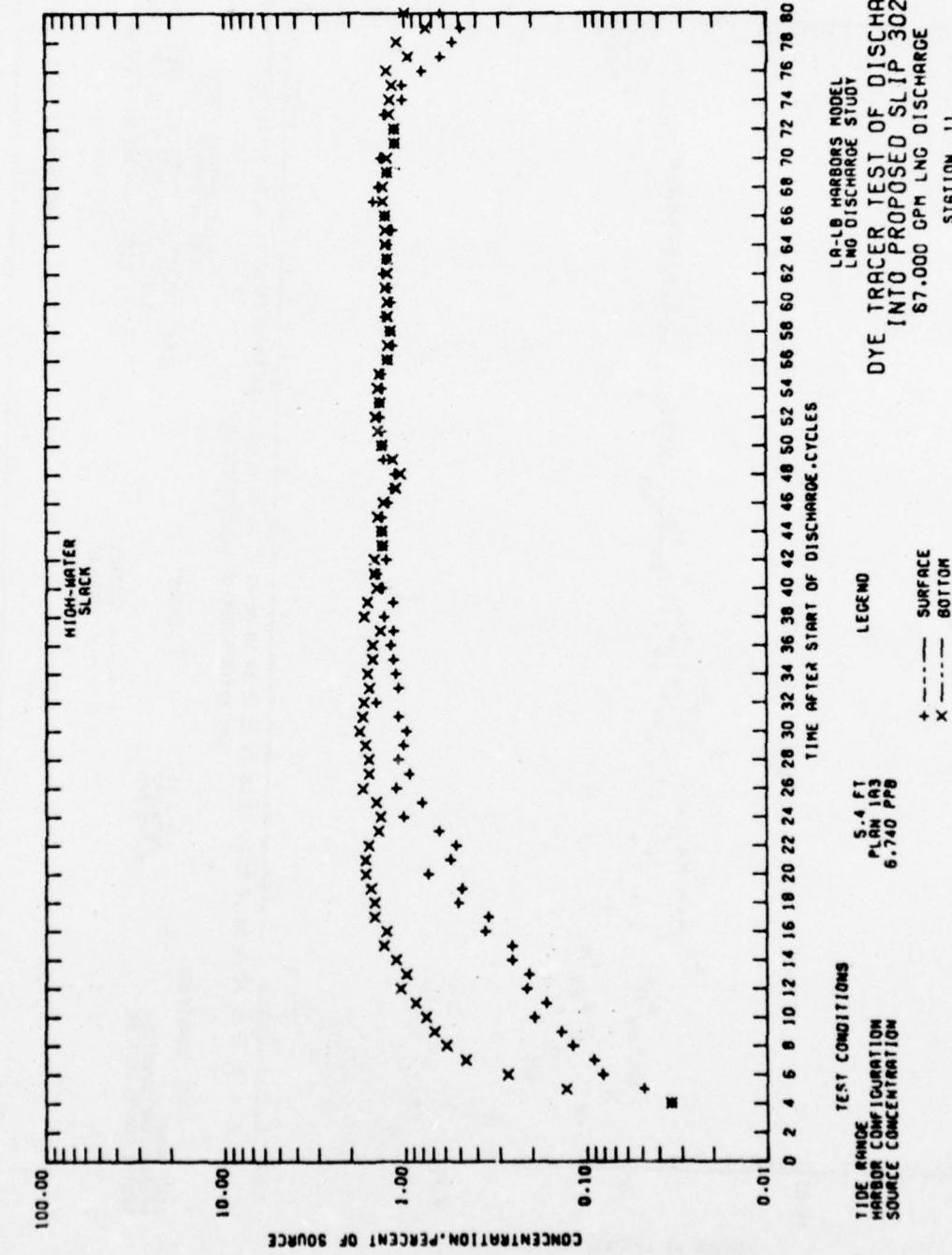
5.4 FT
PLAN 1A3
6,740 PPB

LEGEND

+ —— SURFACE
x —— BOTTOM

PRELIMINARY DATA

PLATE 1.29



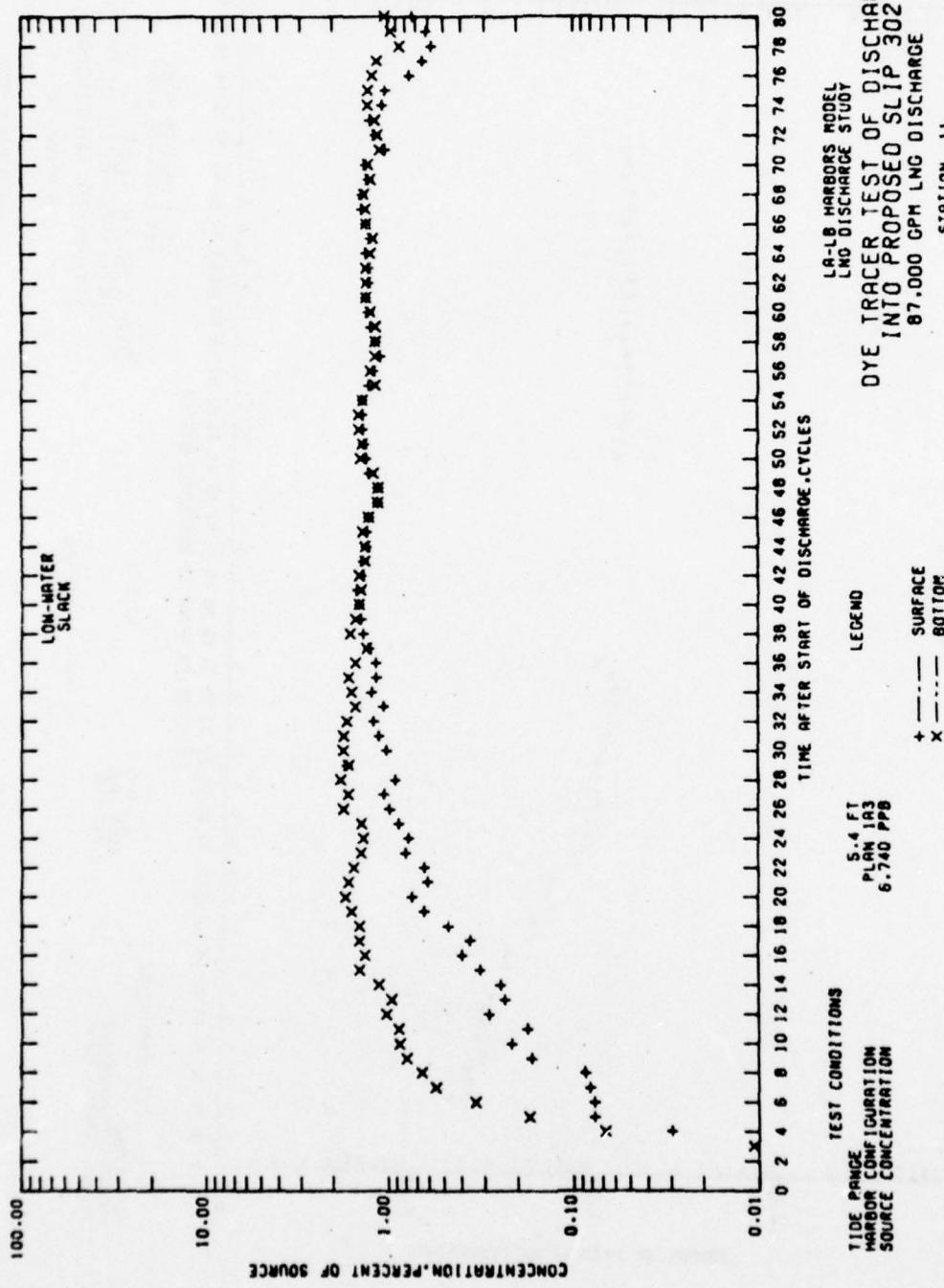
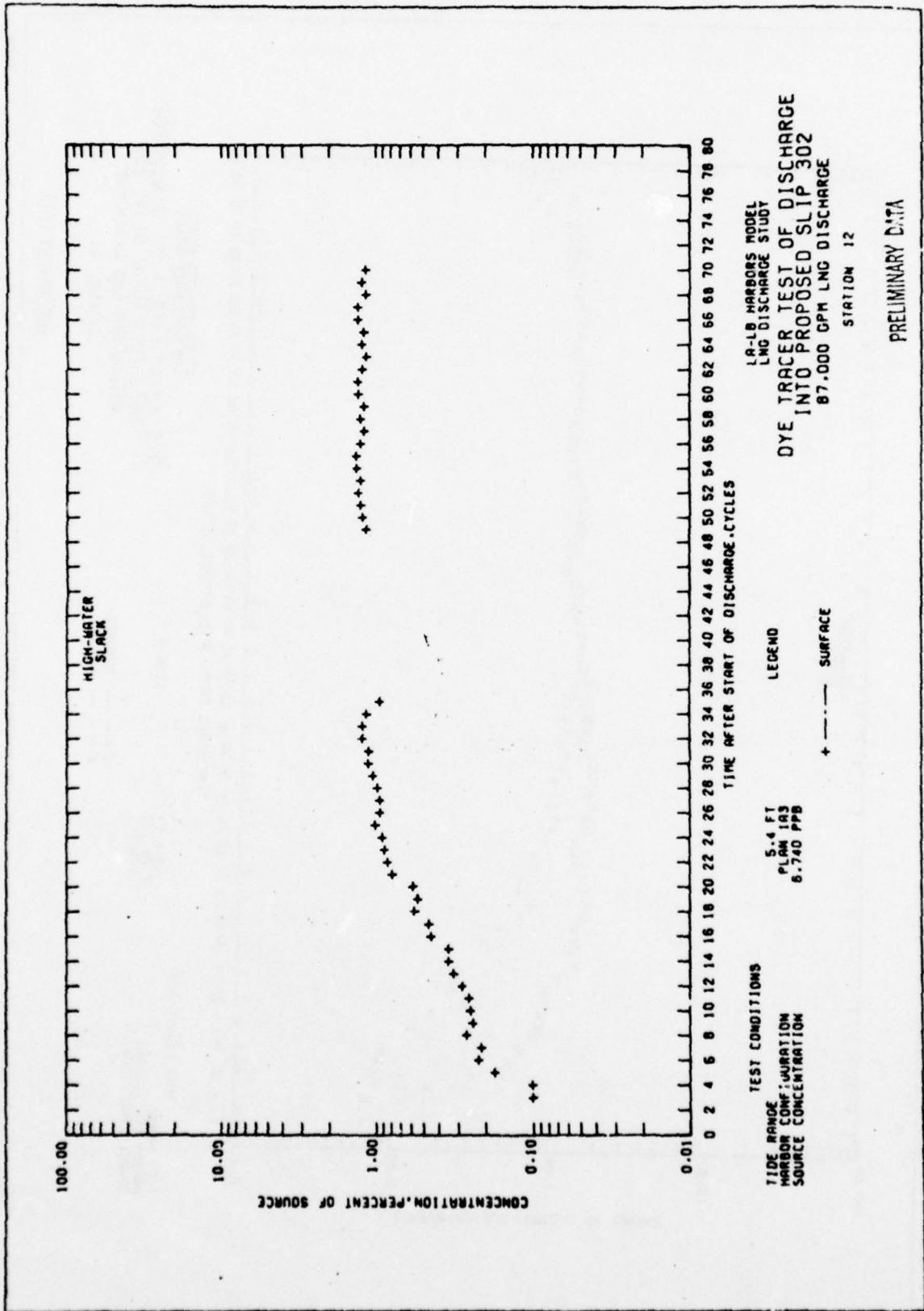
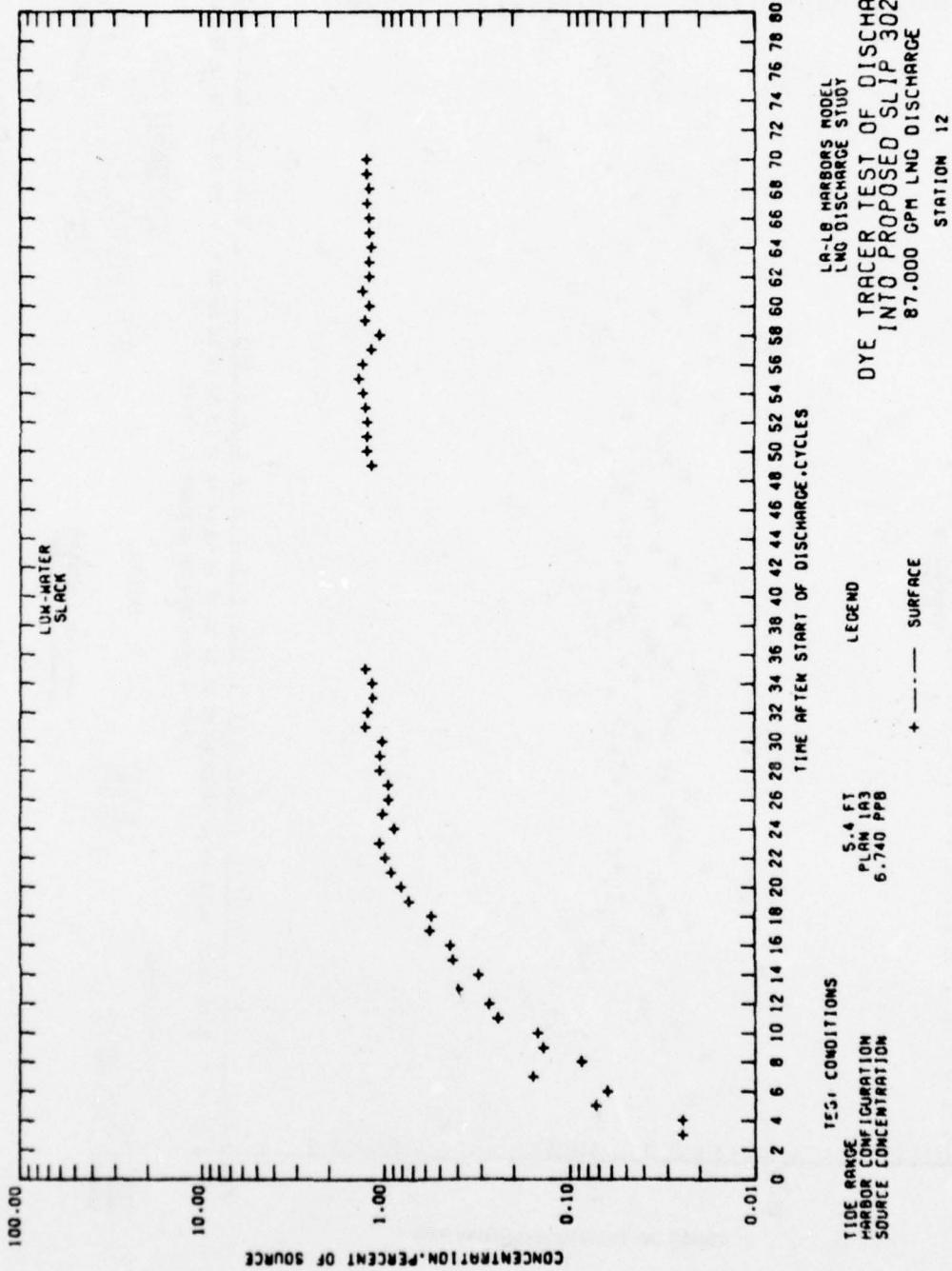
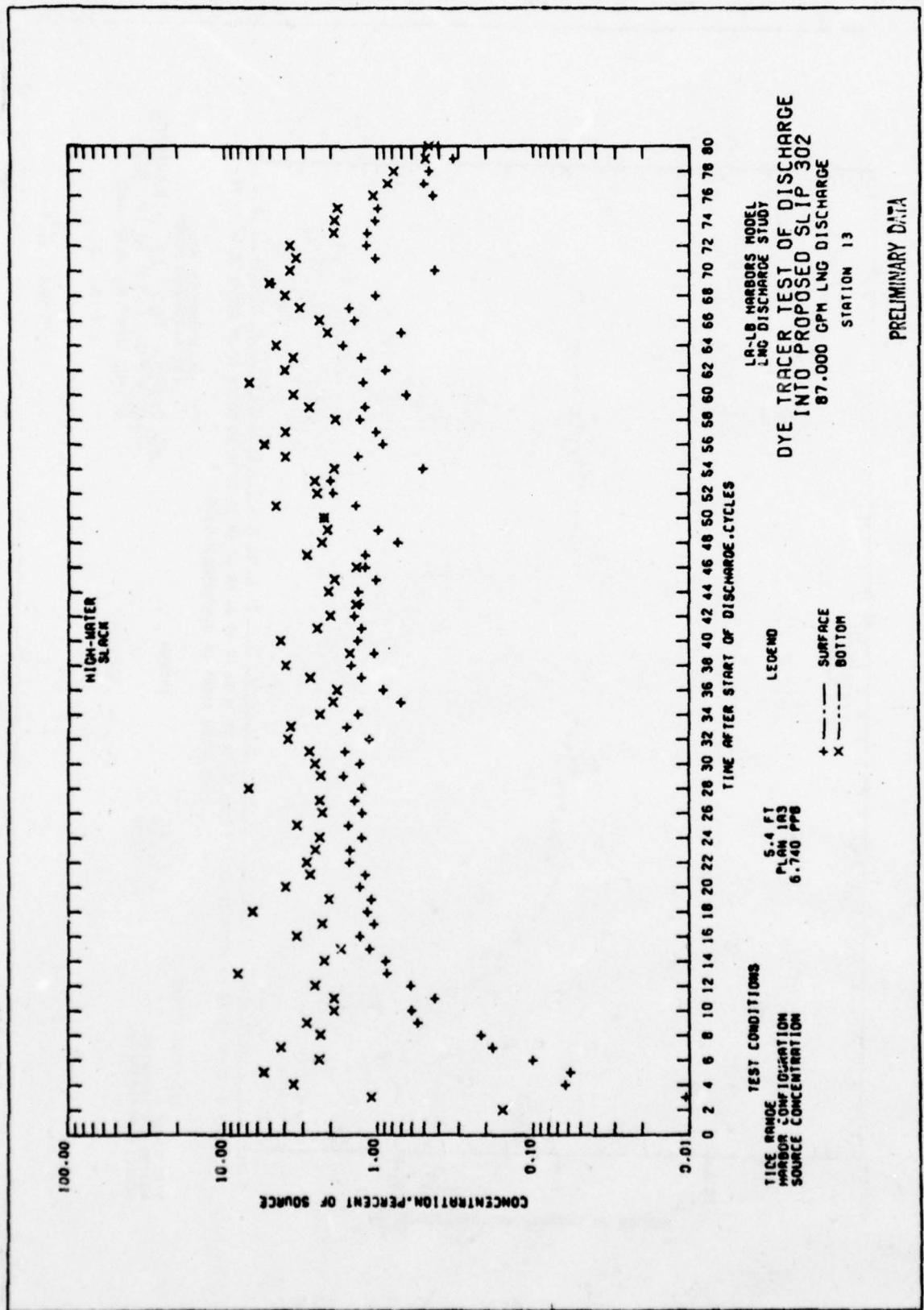
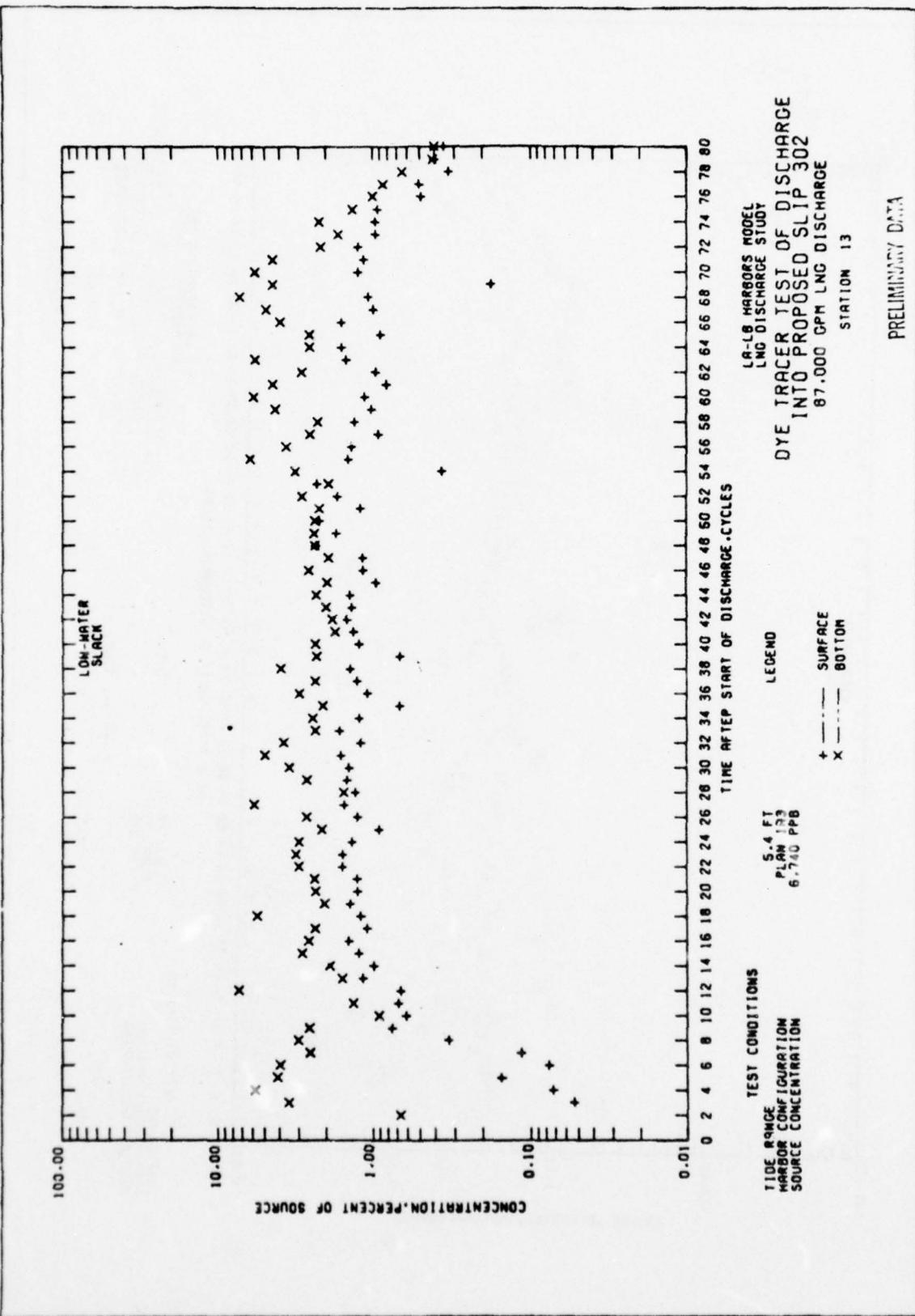


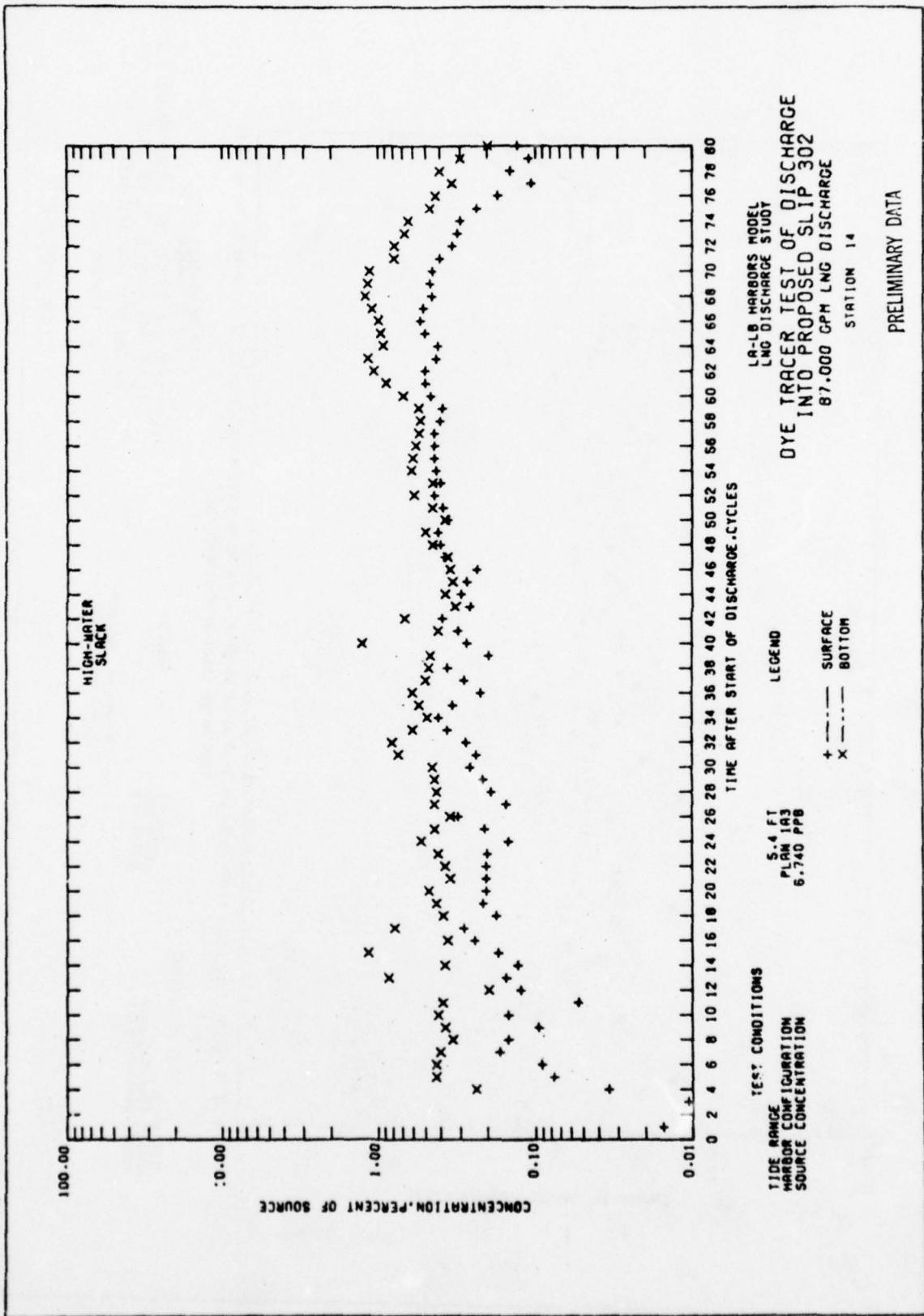
PLATE L51

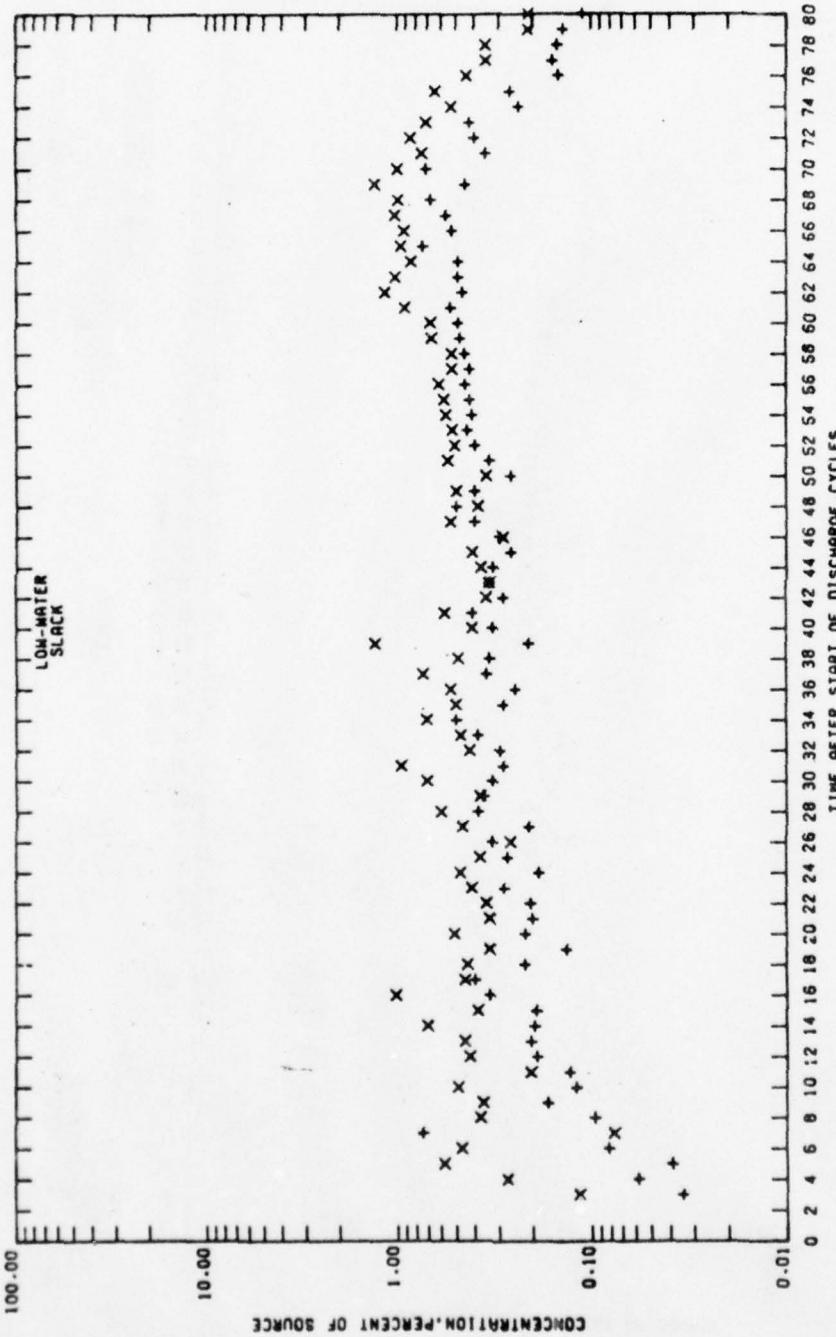










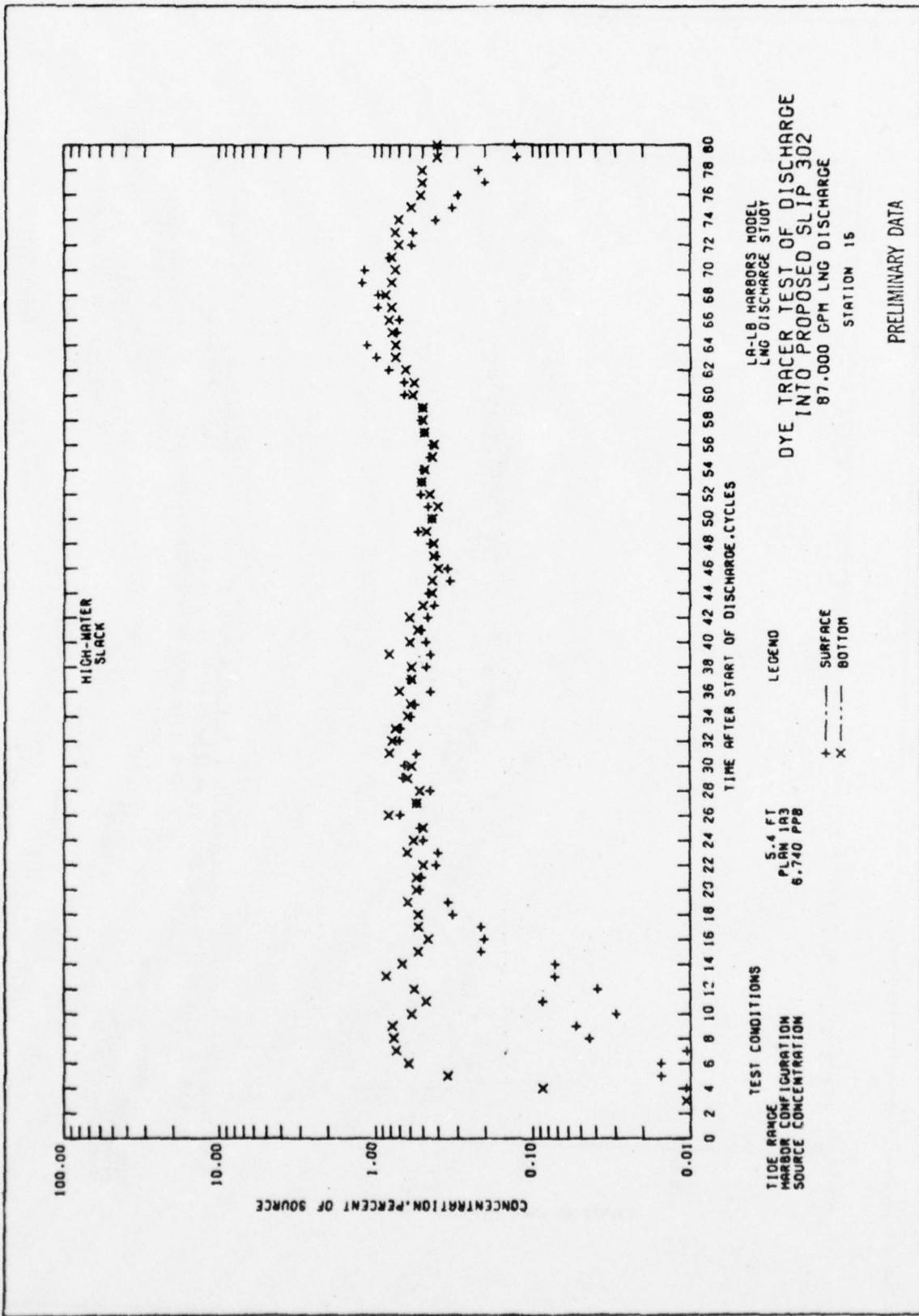


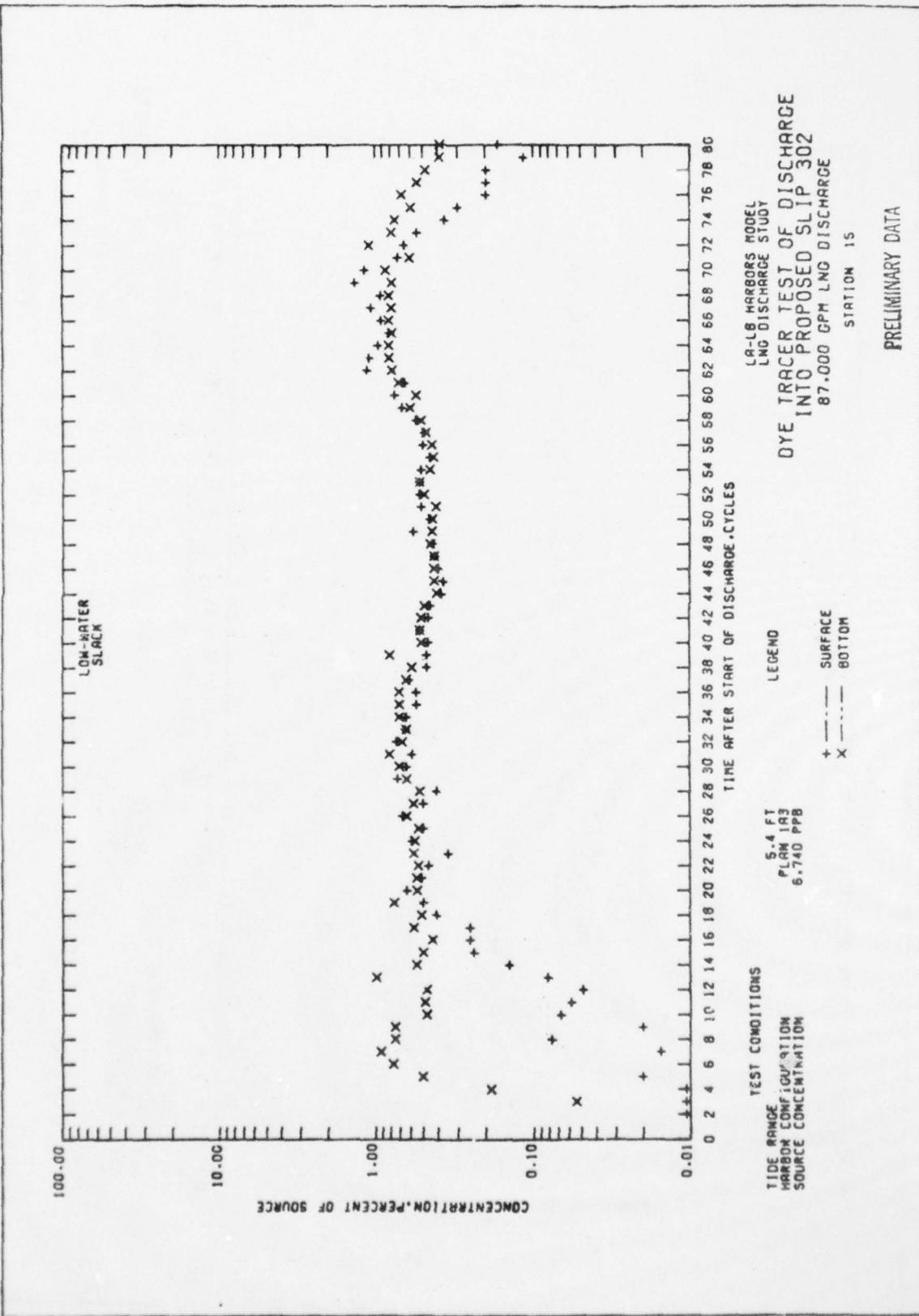
LA-LB HARBOURS MODEL,
LNG DISCHARGE STUDY
DYE TRACER TEST OF DISCHARGE
INTO PROPOSED SLIP 302
87,000 GPM LNG DISCHARGE

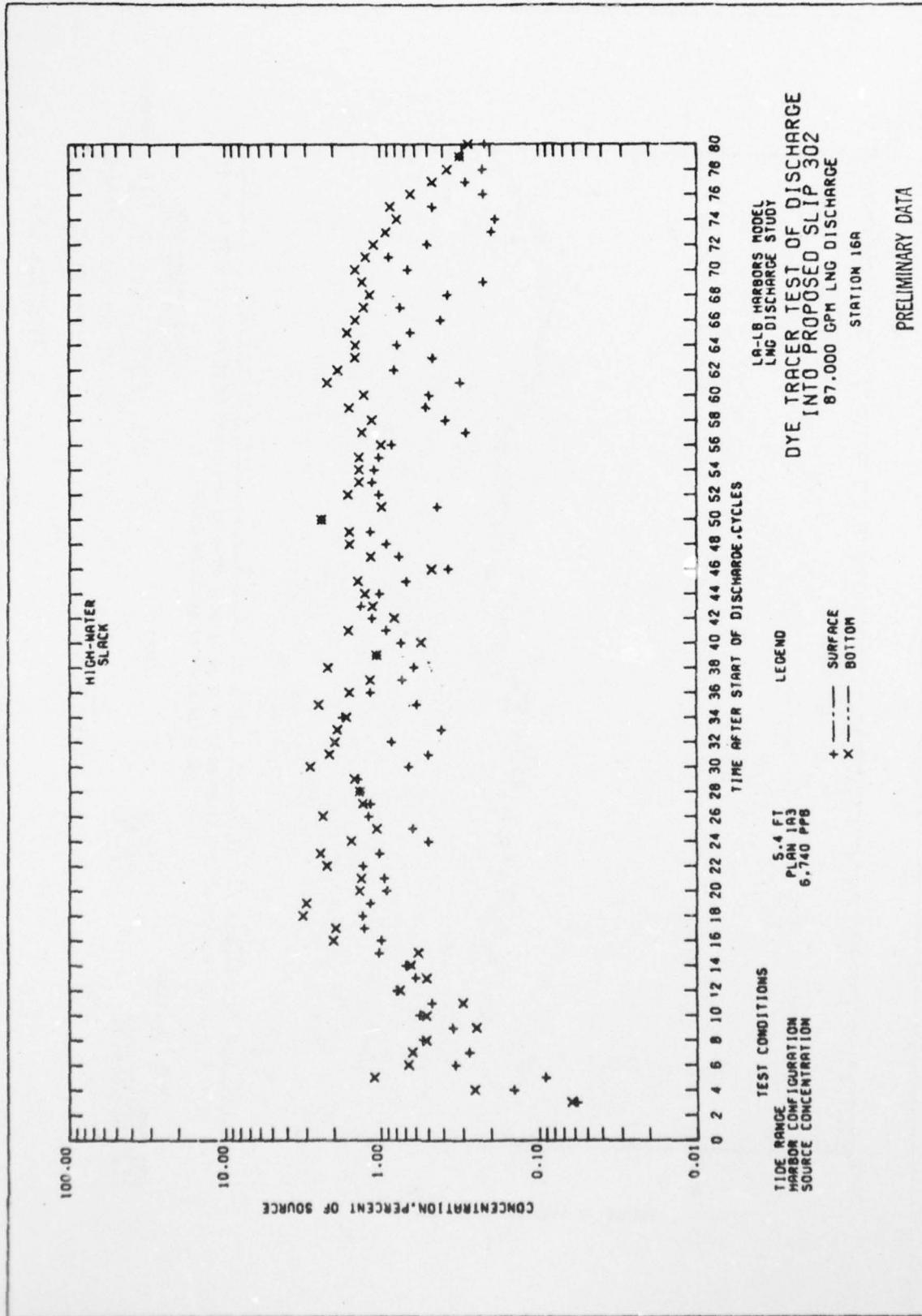
STATION 14

PRELIMINARY DATA

PLATE LS-7







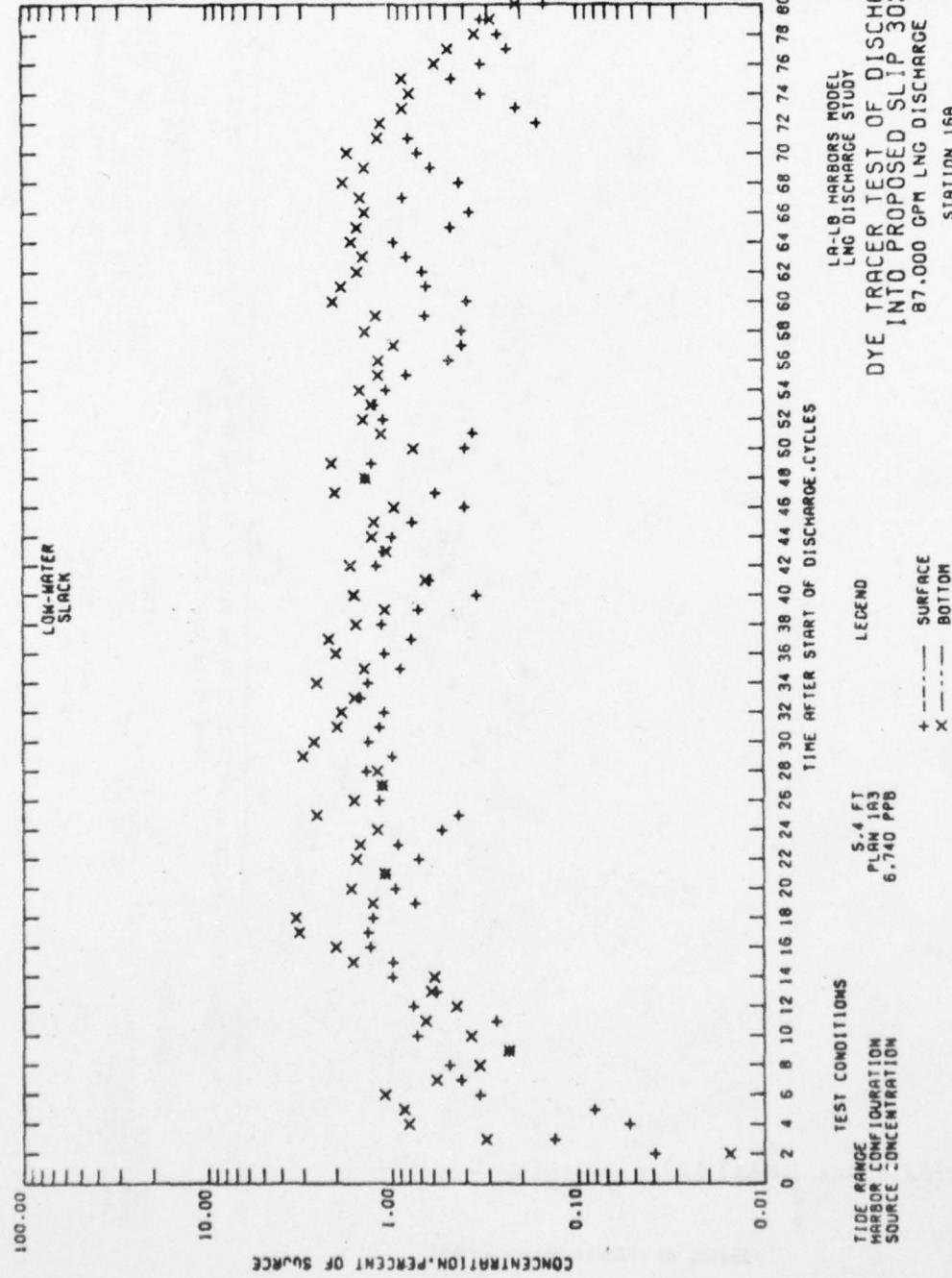
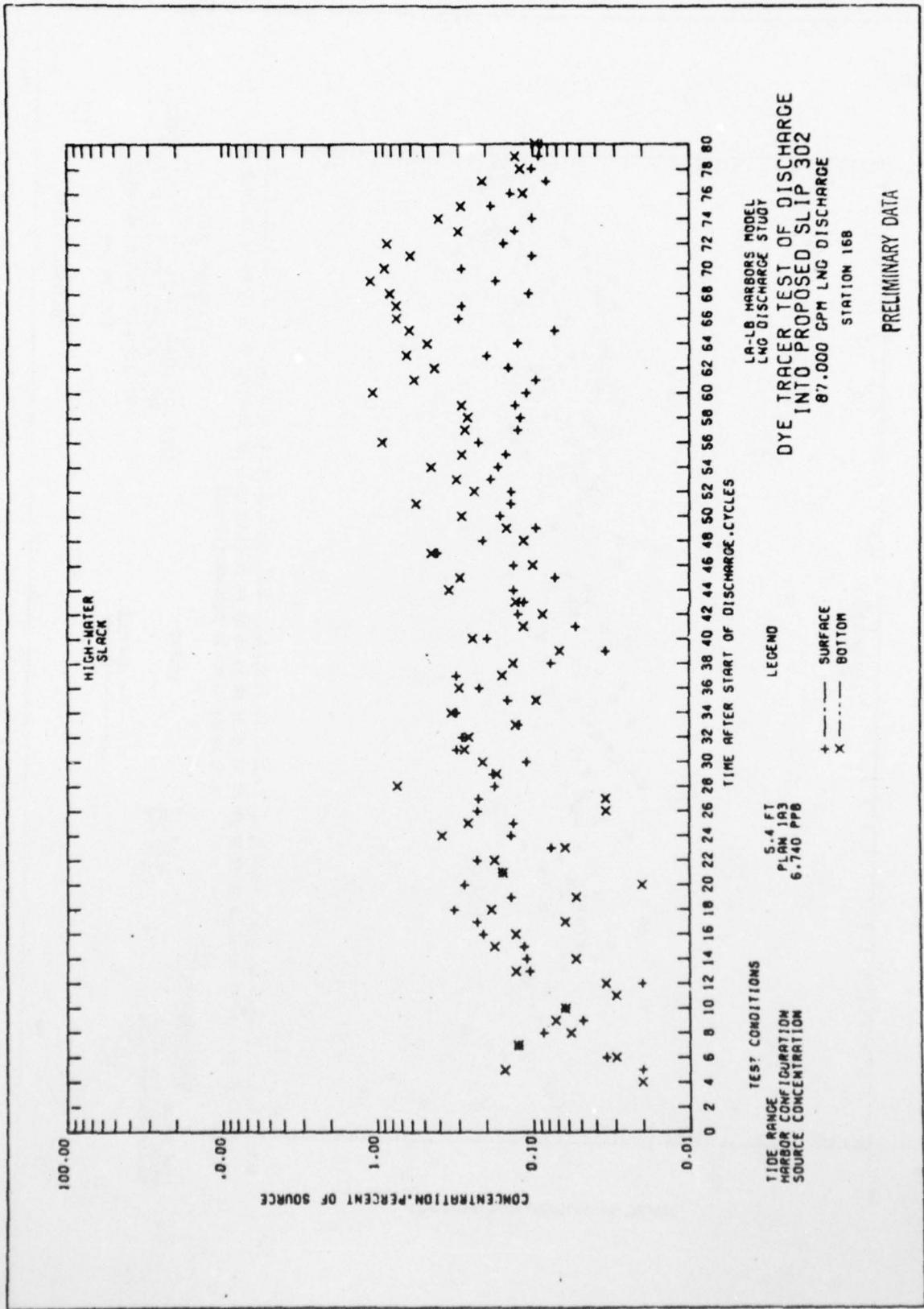
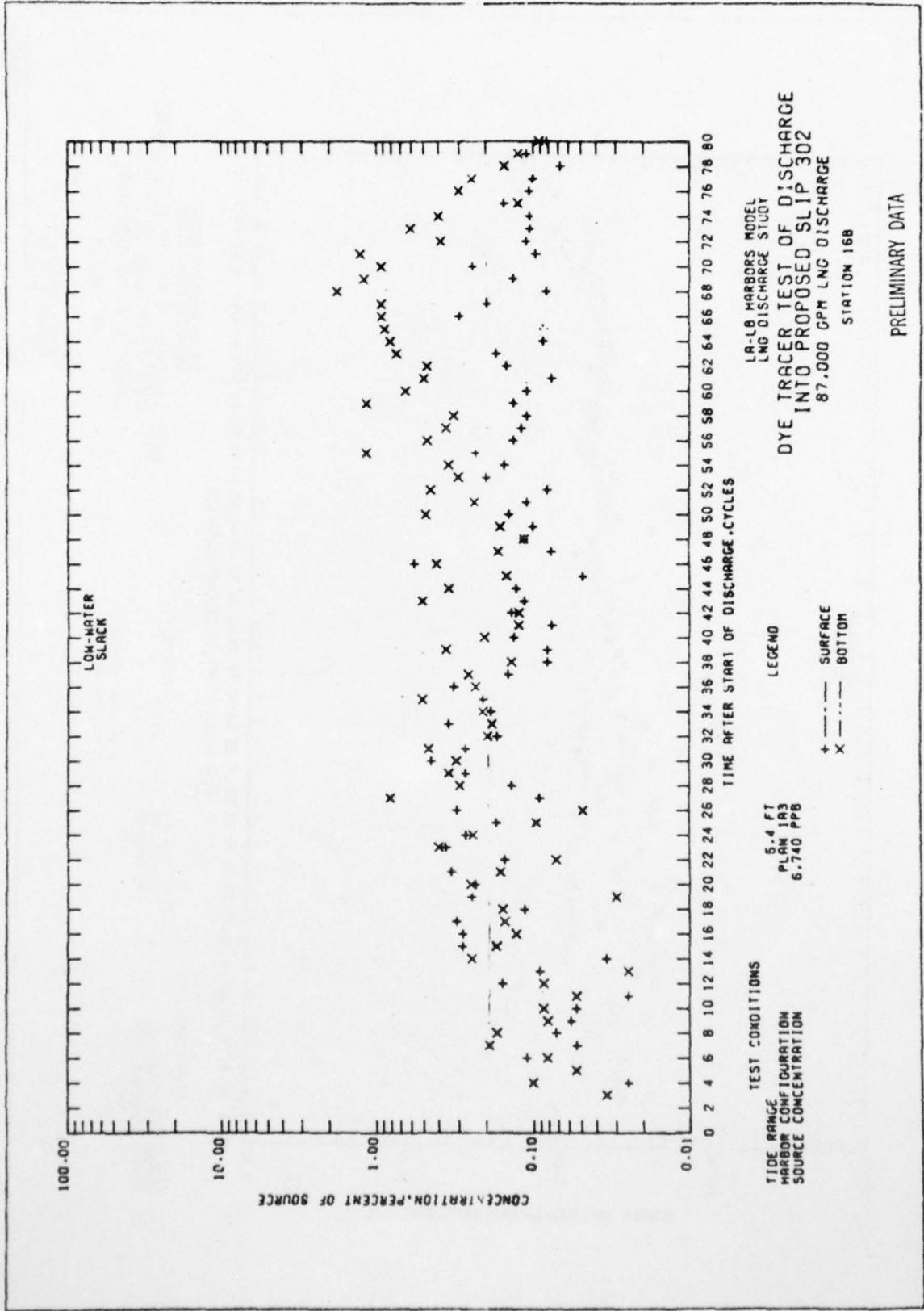
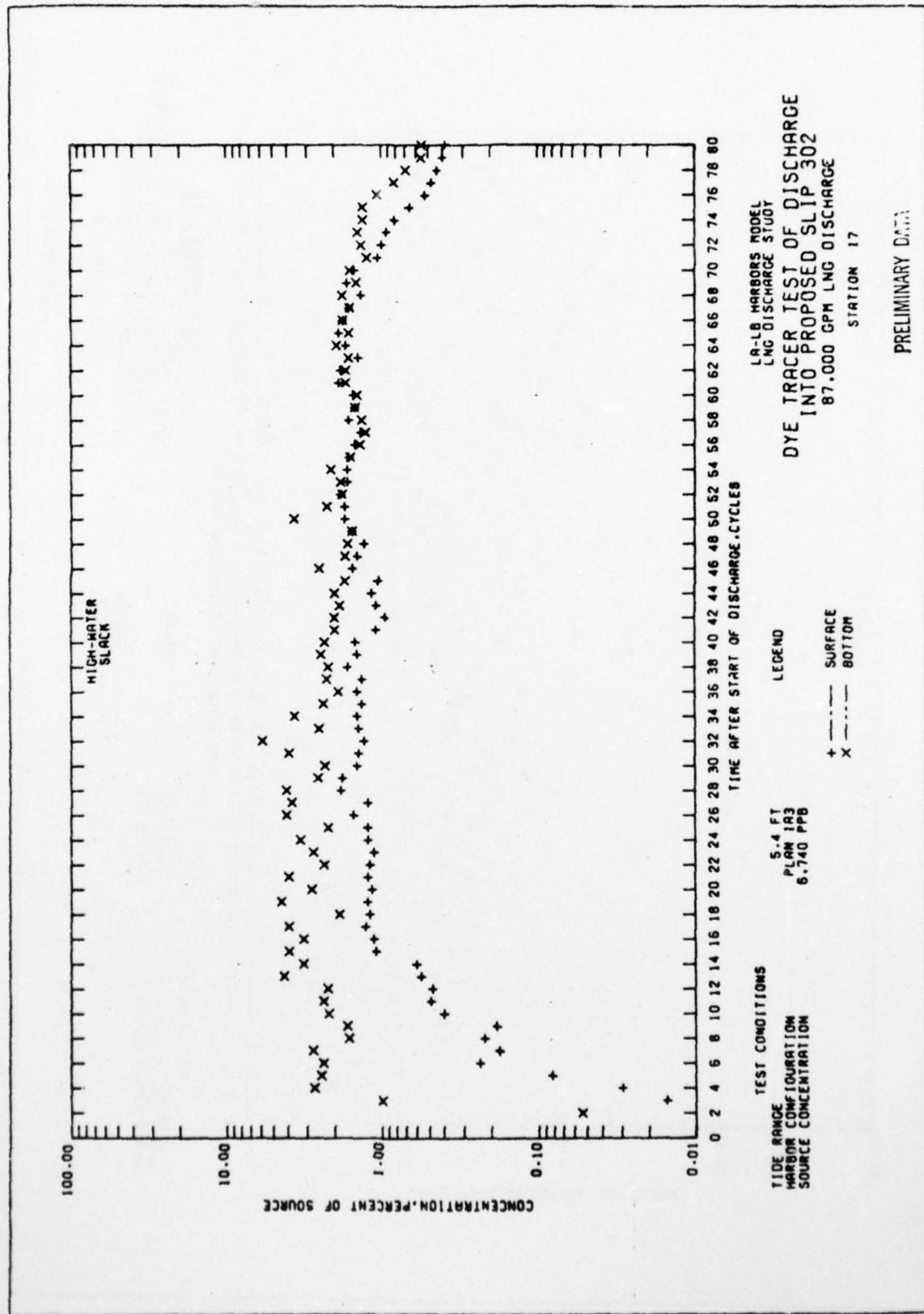
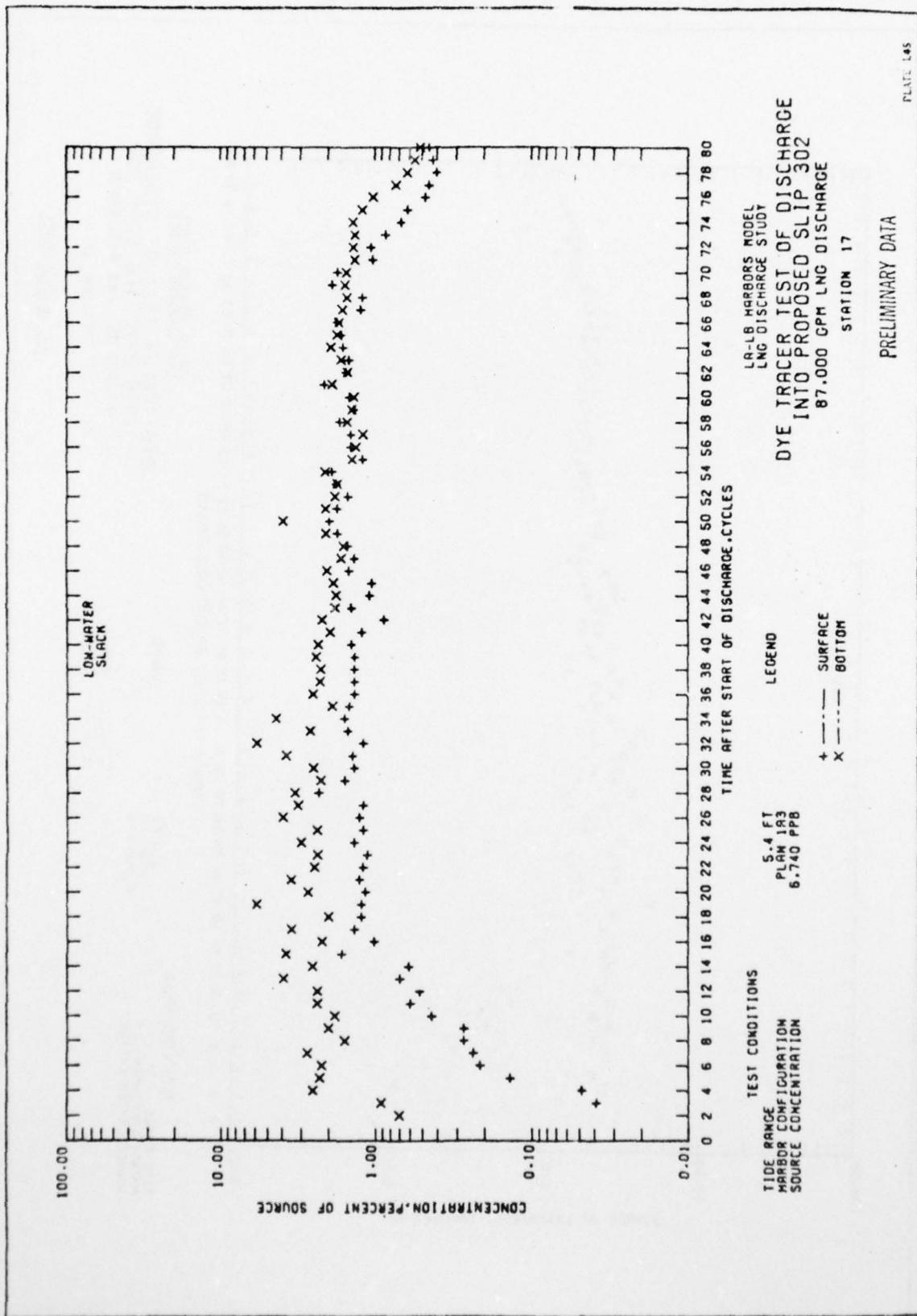


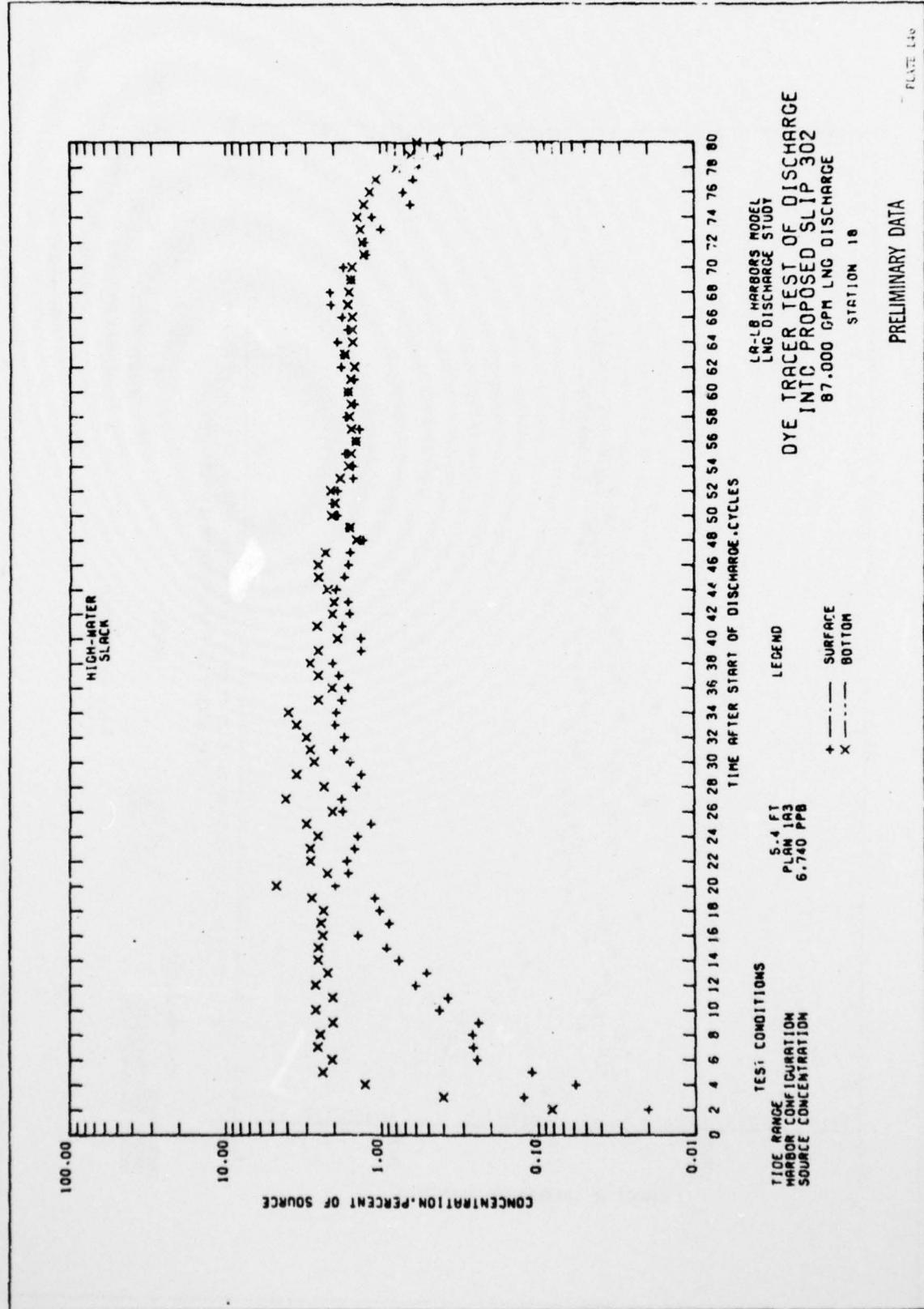
PLATE L-11

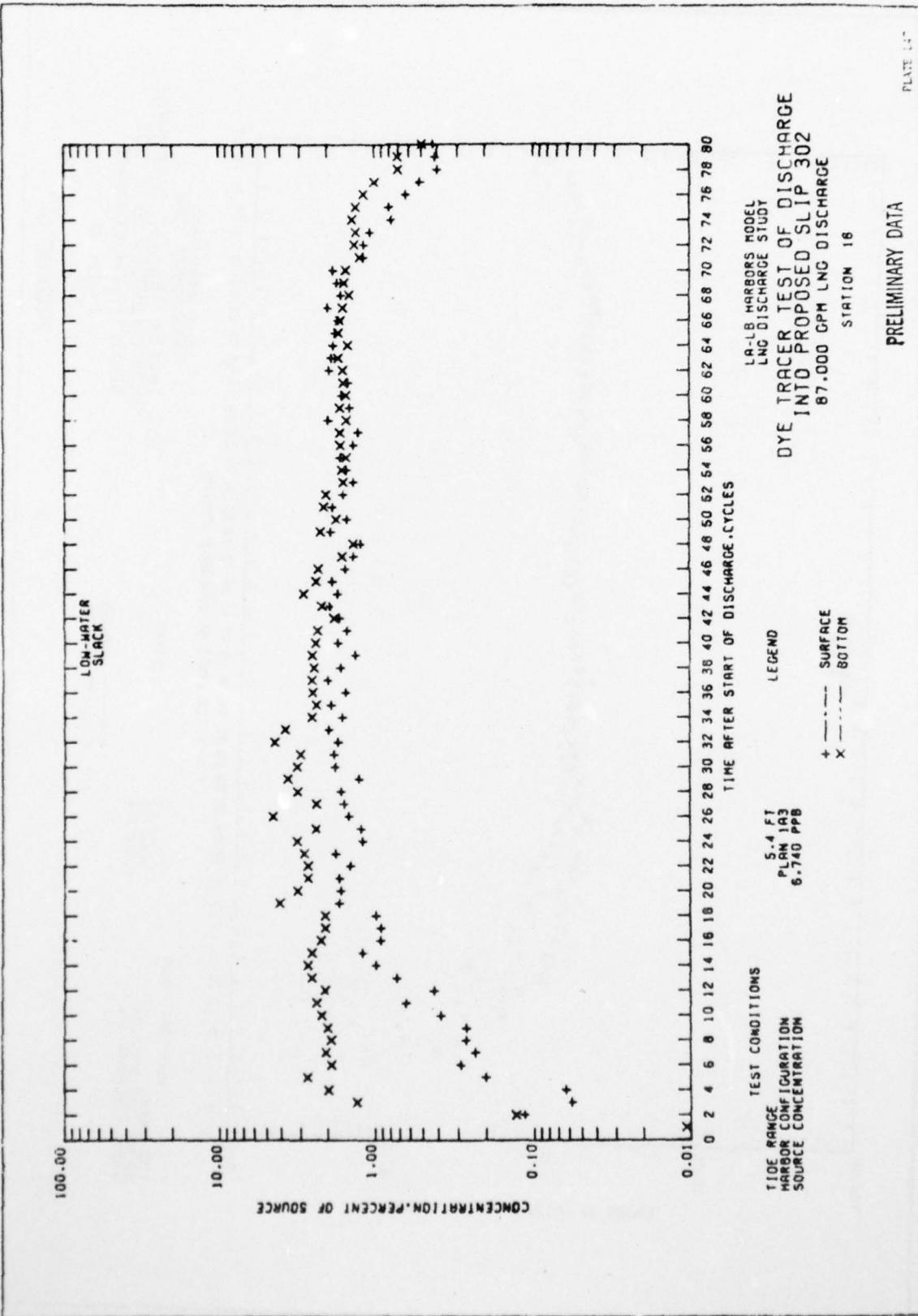


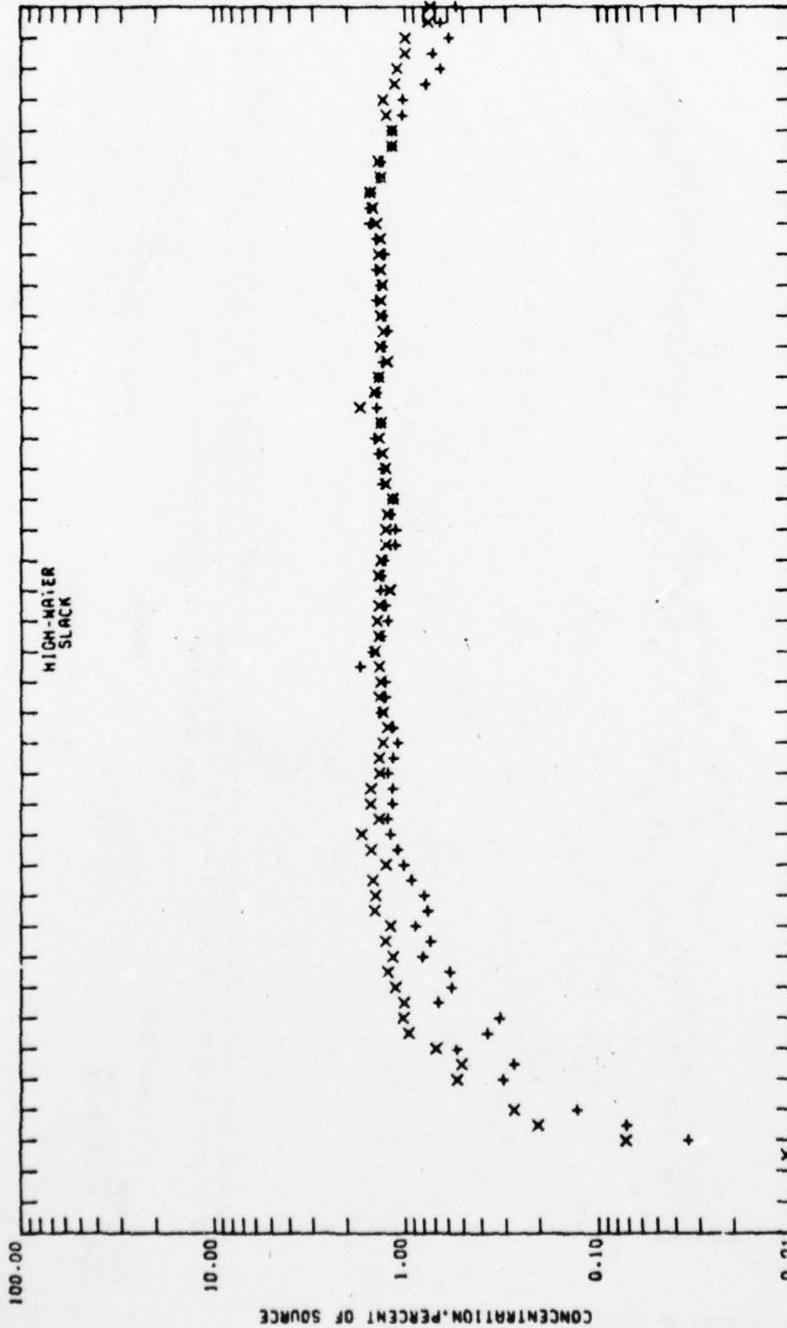






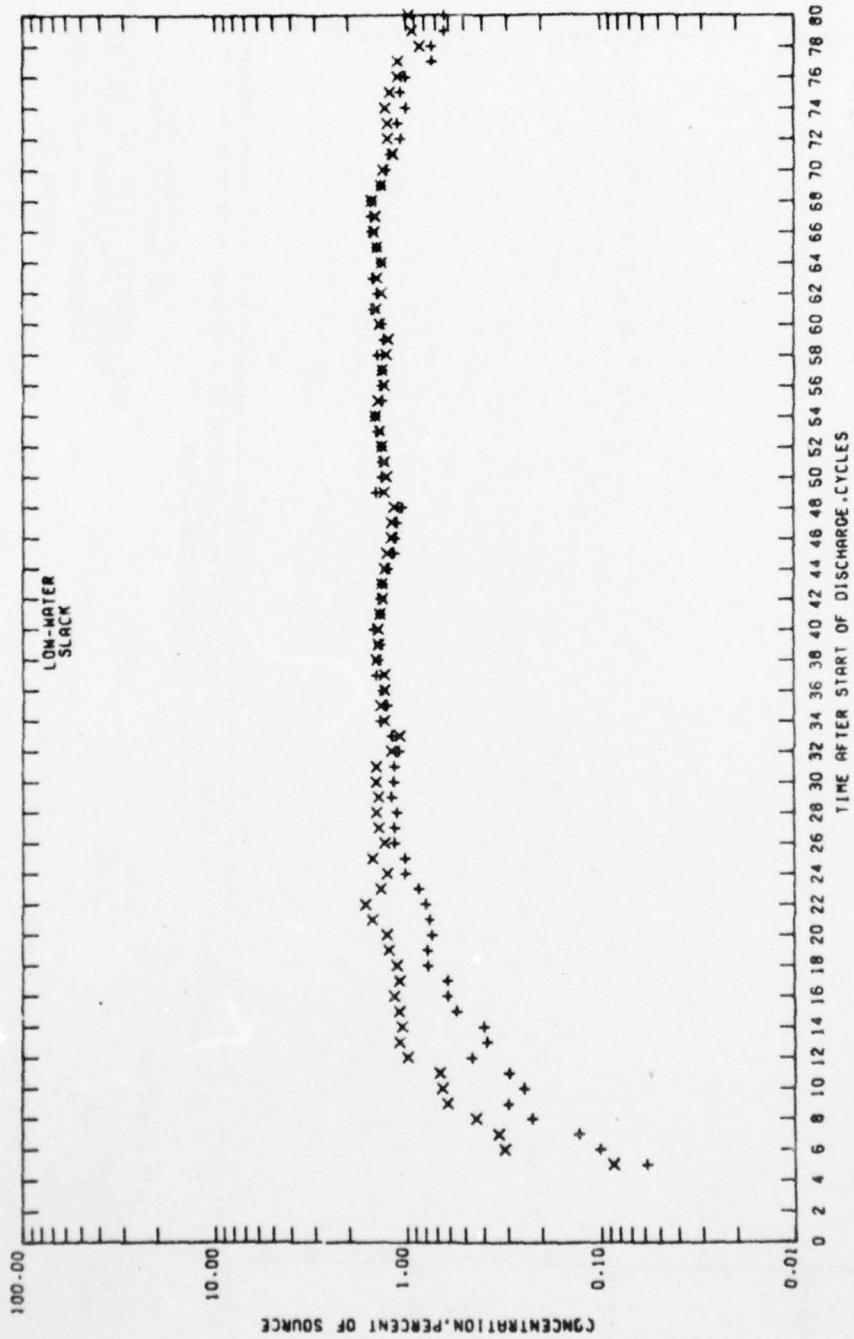






LA-LB HARBORS MODEL
 LNG DISCHARGE STUDY
 DYE TRACER TEST OF DISCHARGE
 INTO PROPOSED SLIP 302
 87,000 GPM LNG DISCHARGE

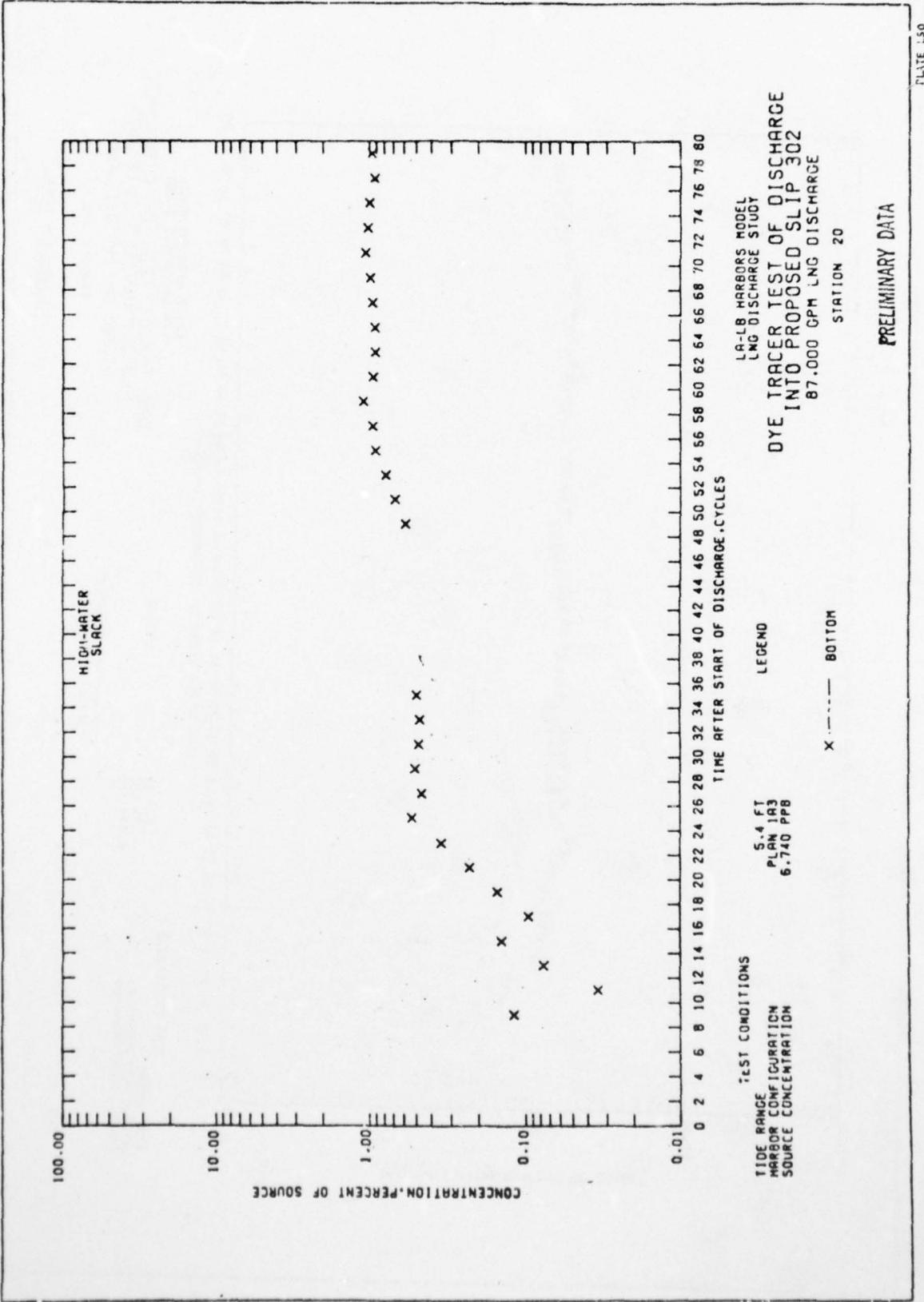
PRELIMINARY DATA

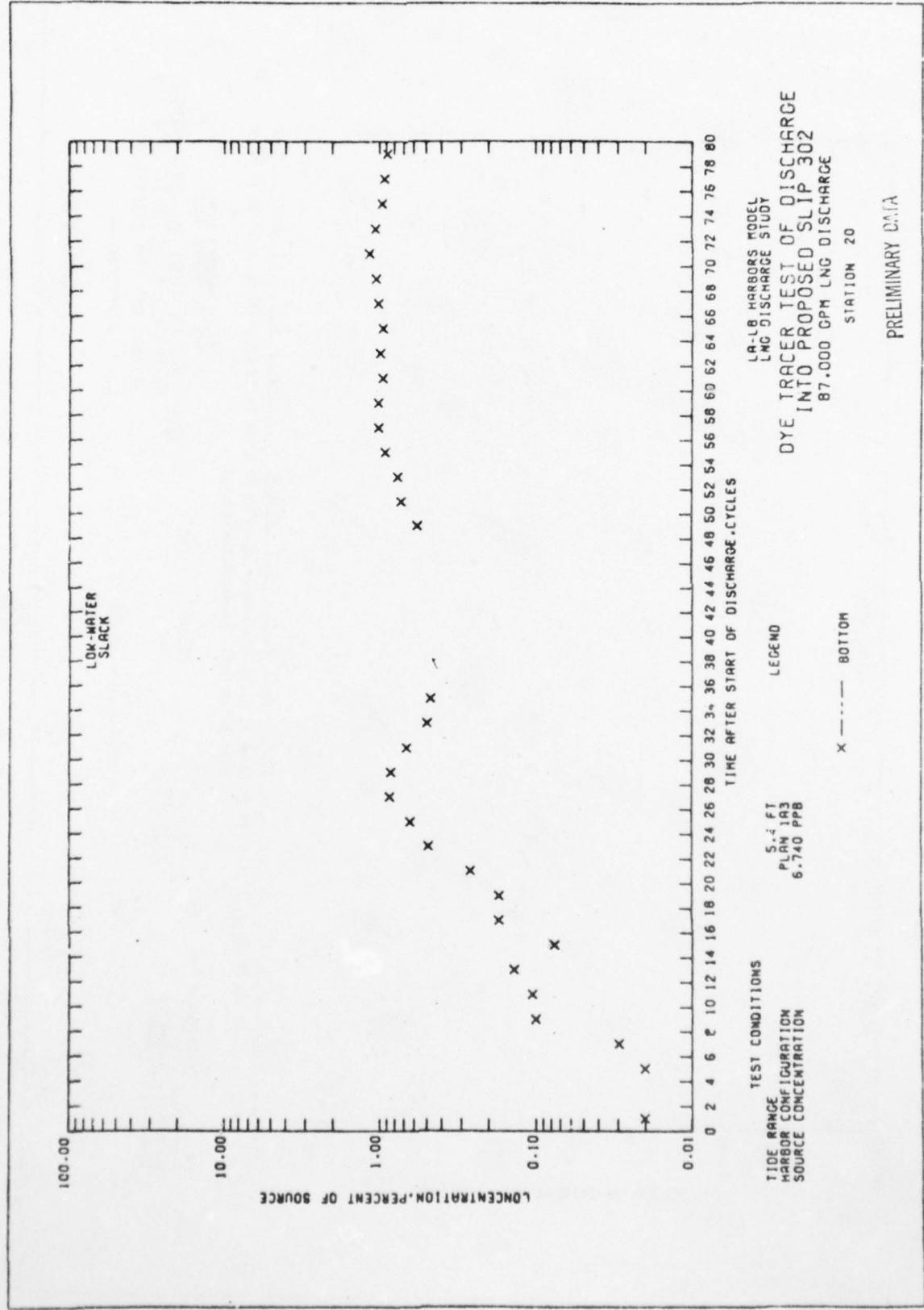


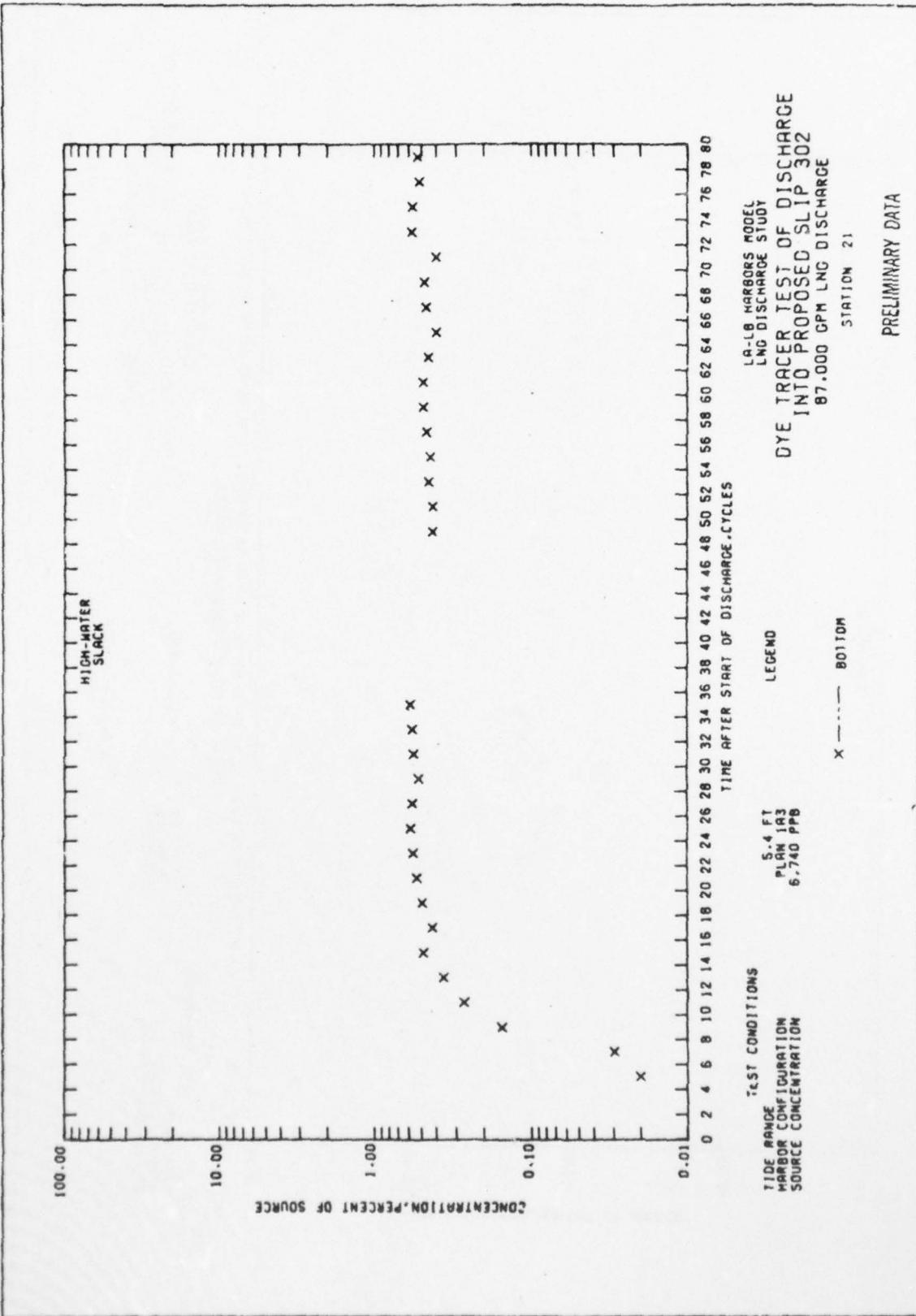
LA-1B HARBOURS MODEL
LNG DISCHARGE STUDY
DYE TRACER TEST OF DISCHARGE
INTO PROPOSED SLIP 302
87,000 GPM LNG DISCHARGE
STATION 19

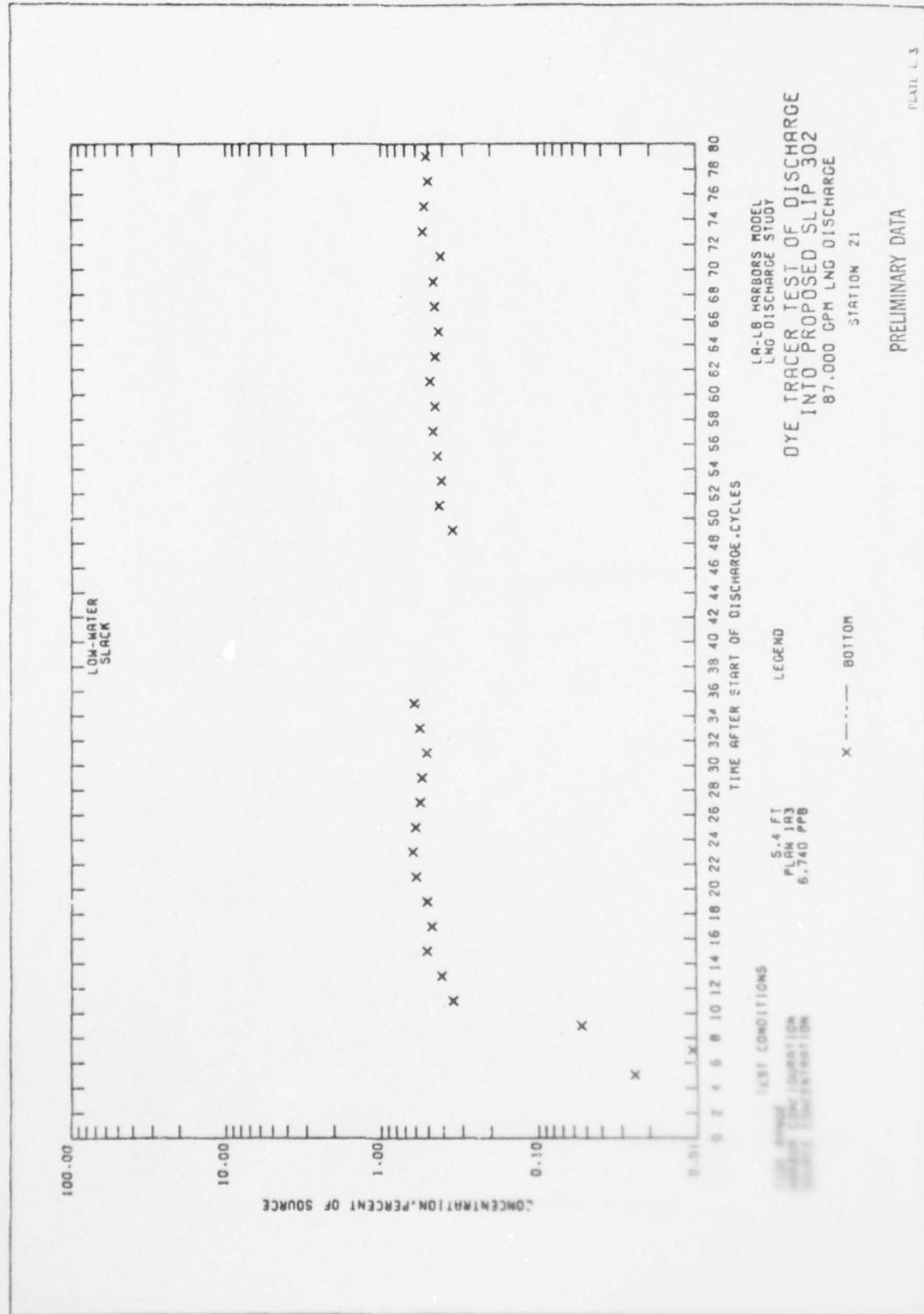
TEST CONDITIONS
TIDE RANGE 5.4 FT
HARBOR CONFIGURATION PLAN 1A3
SOURCE CONCENTRATION 6,740 PPB
LEGEND
+ — SURFACE
X — BOTTOM

PRELIMINARY DATA
PLATE LA-9









AD-A050 023

ARMY ENGINEER WATERWAYS EXPERIMENT STATION VICKSBURG MISS F/8 14/2
MODEL STUDY OF COOL WATER DISCHARGE FROM PROPOSED LNG FACILITY --ETC(U)
NOV 77 W H MCANALLY

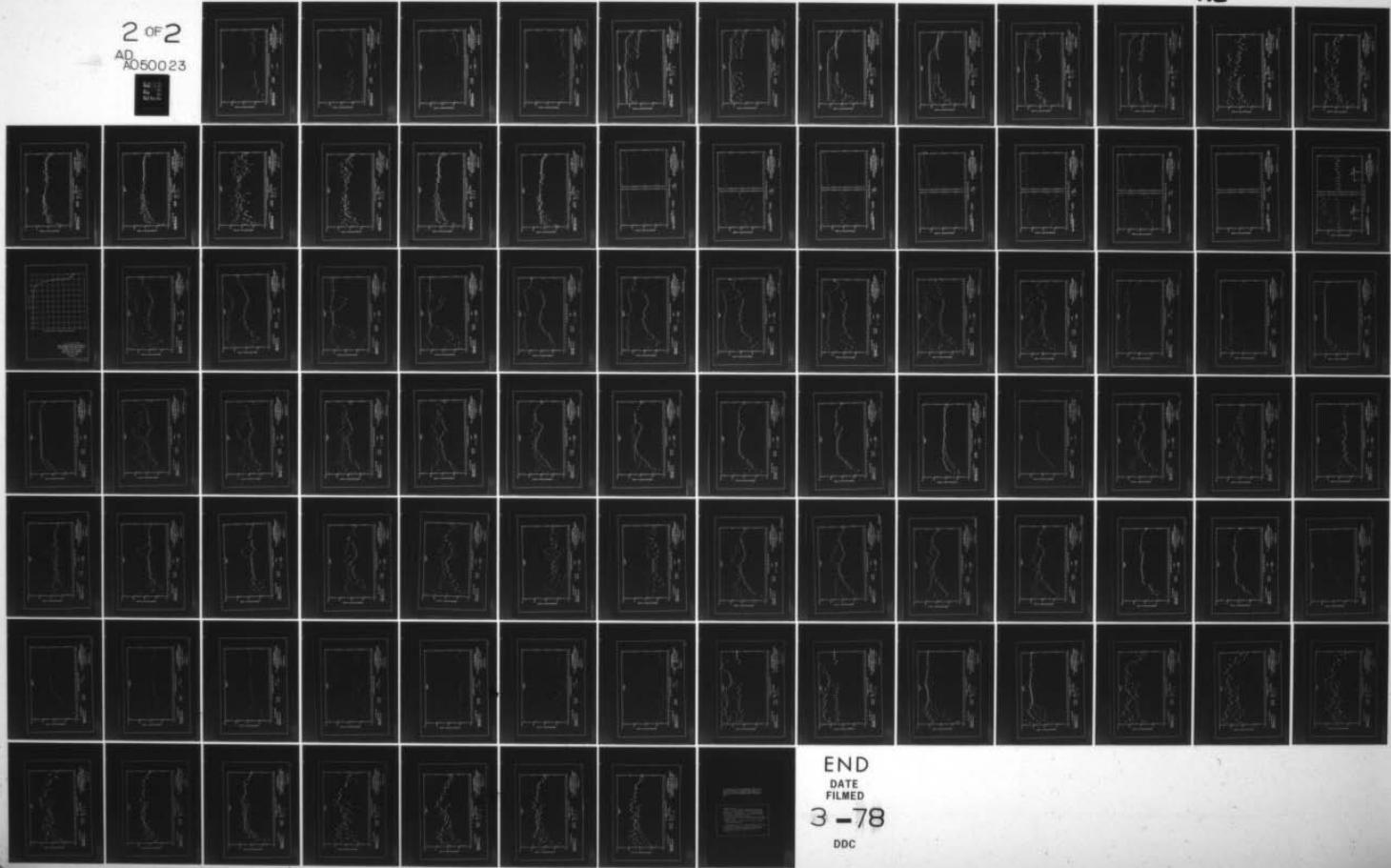
UNCLASSIFIED

WES-MP-H-77-13

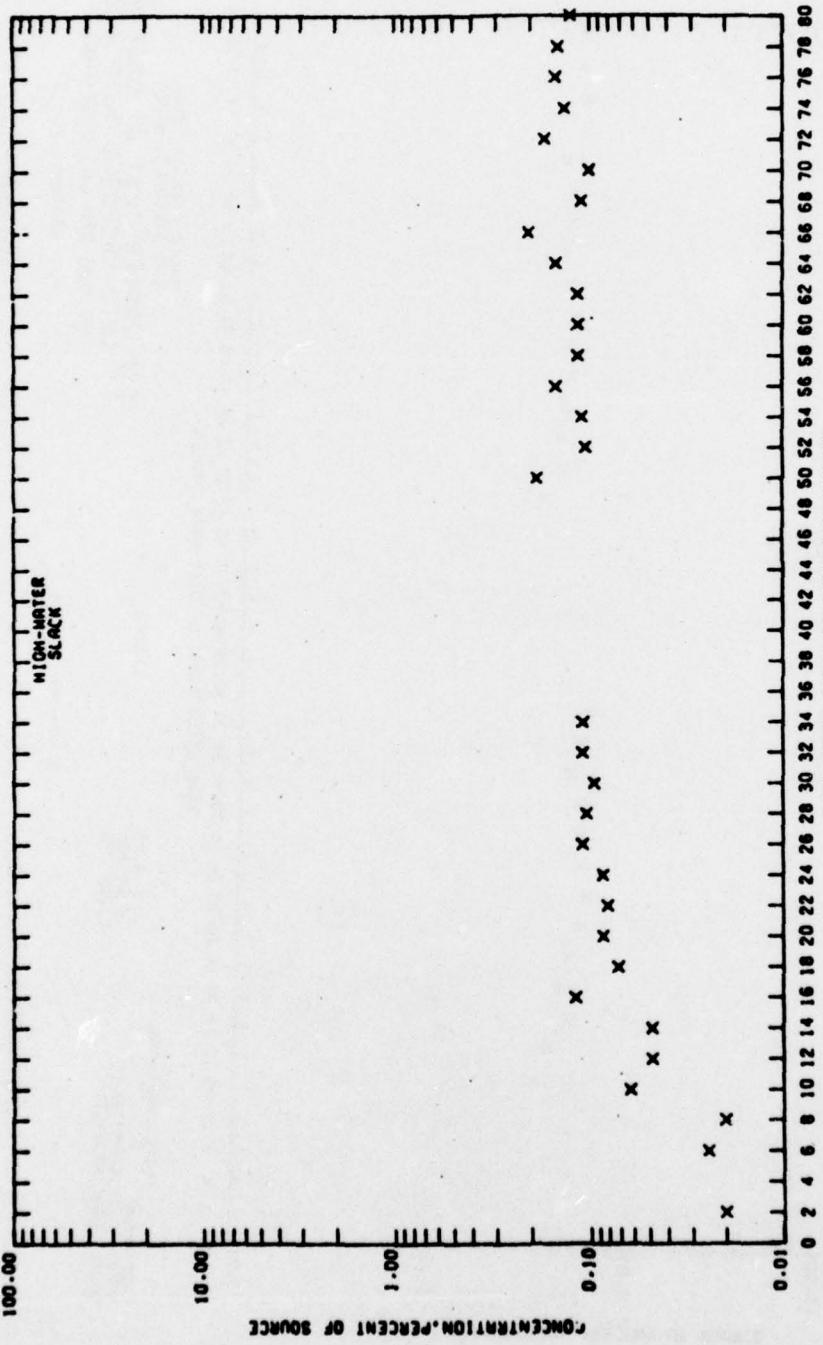
NL

2 OF 2

AD
A050023



END
DATE
FILED
3-78
DDC



LA-16 MARBOS MODEL
LNG DISCHARGE STUDY
DYE TRACER TEST OF DISCHARGE
INTO PROPOSED SLIP 302
87,000 GPM LNG DISCHARGE
STATION 22
PRELIMINARY DATA
PLATE 15

TEST CONDITIONS

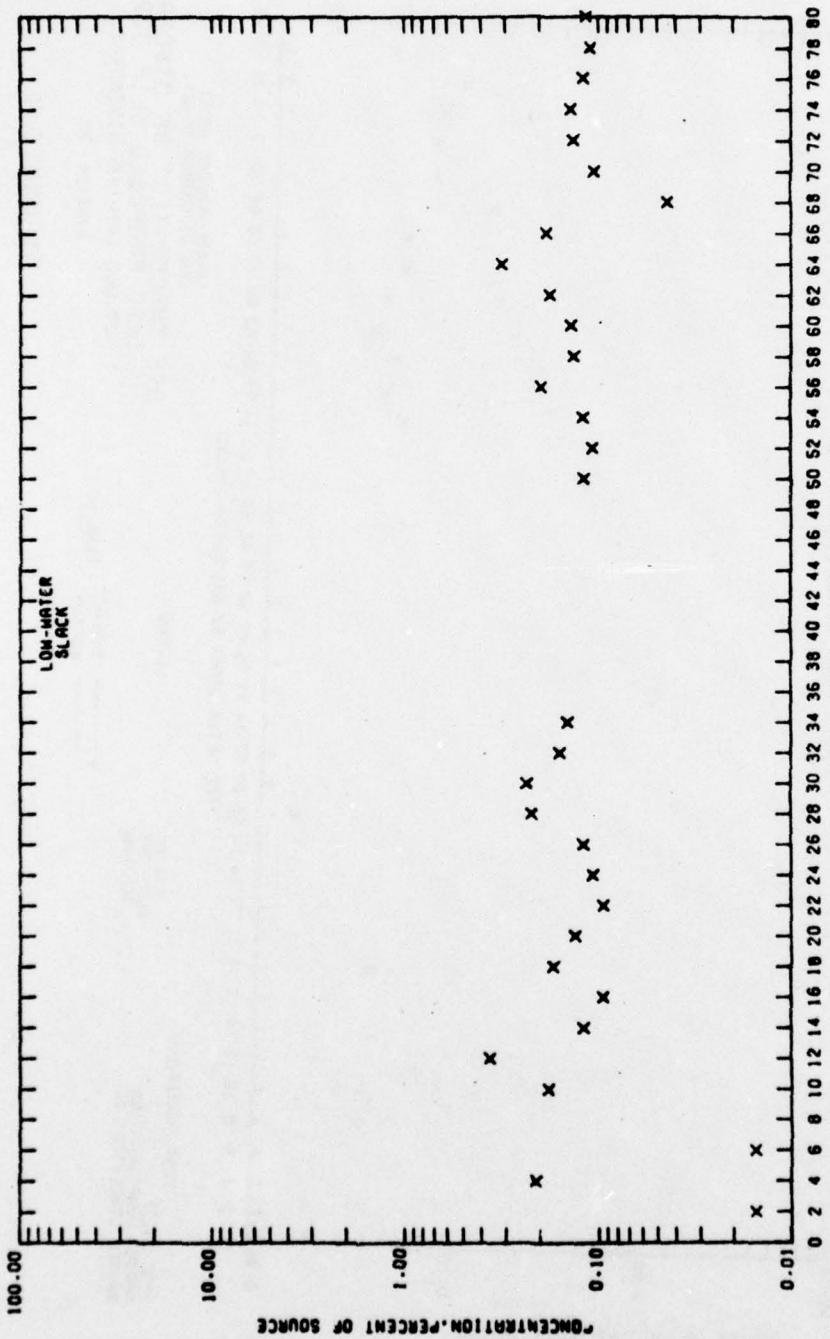
TIDE RANGE 5.4 FT

MARSH CONFIGURATION PLAN 163

SOURCE CONCENTRATION 6,740 PPS

LEGEND

X ----- BOTTOM



LA-LB HARBOURS MODEL
LNG DISCHARGE STUDY
DYE TRACER TEST OF DISCHARGE
INTO PROPOSED SLIP 302
87,000 GPM LNG DISCHARGE
STATION 22

PRELIMINARY DATA

PLATE L-5

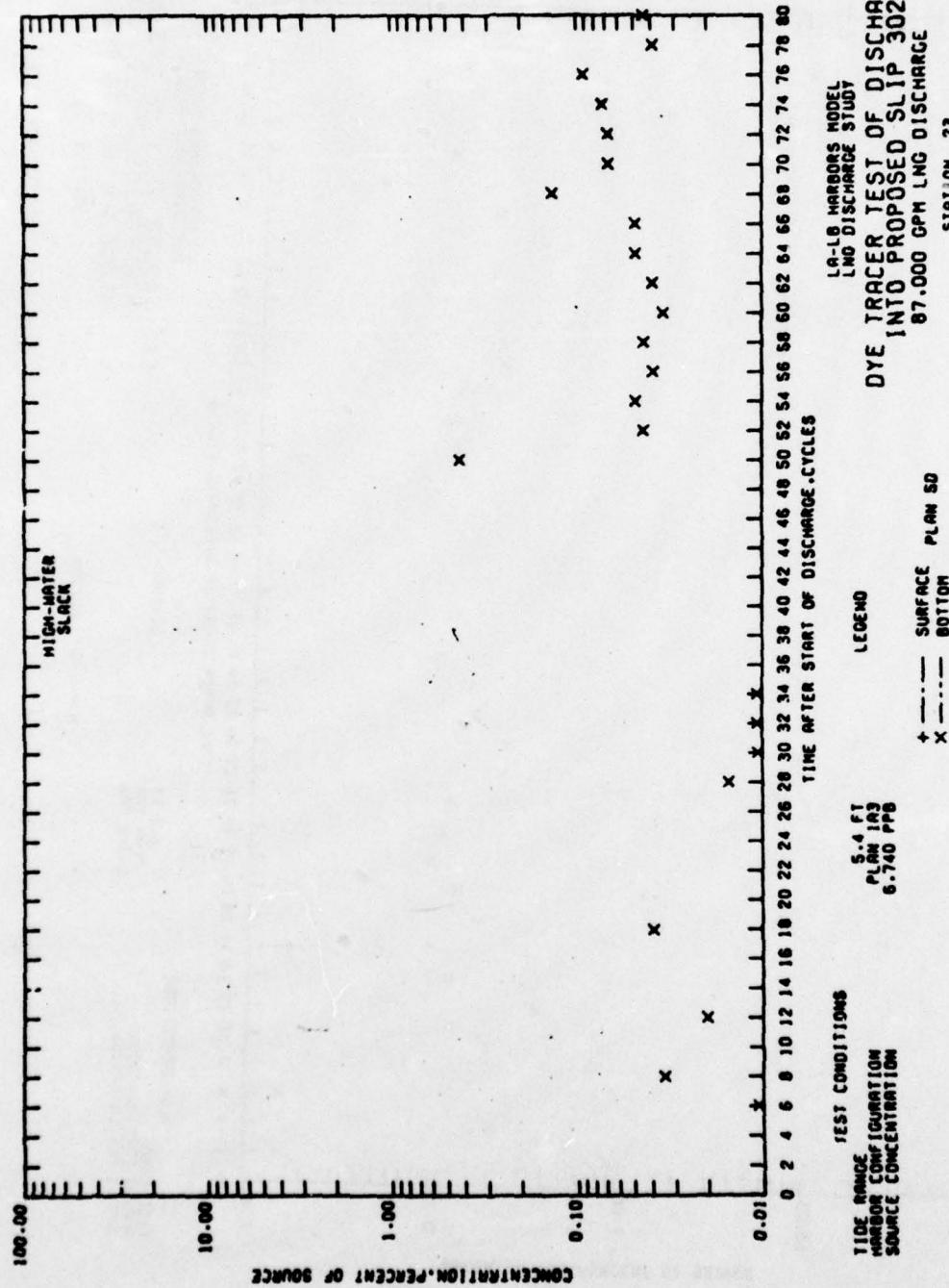
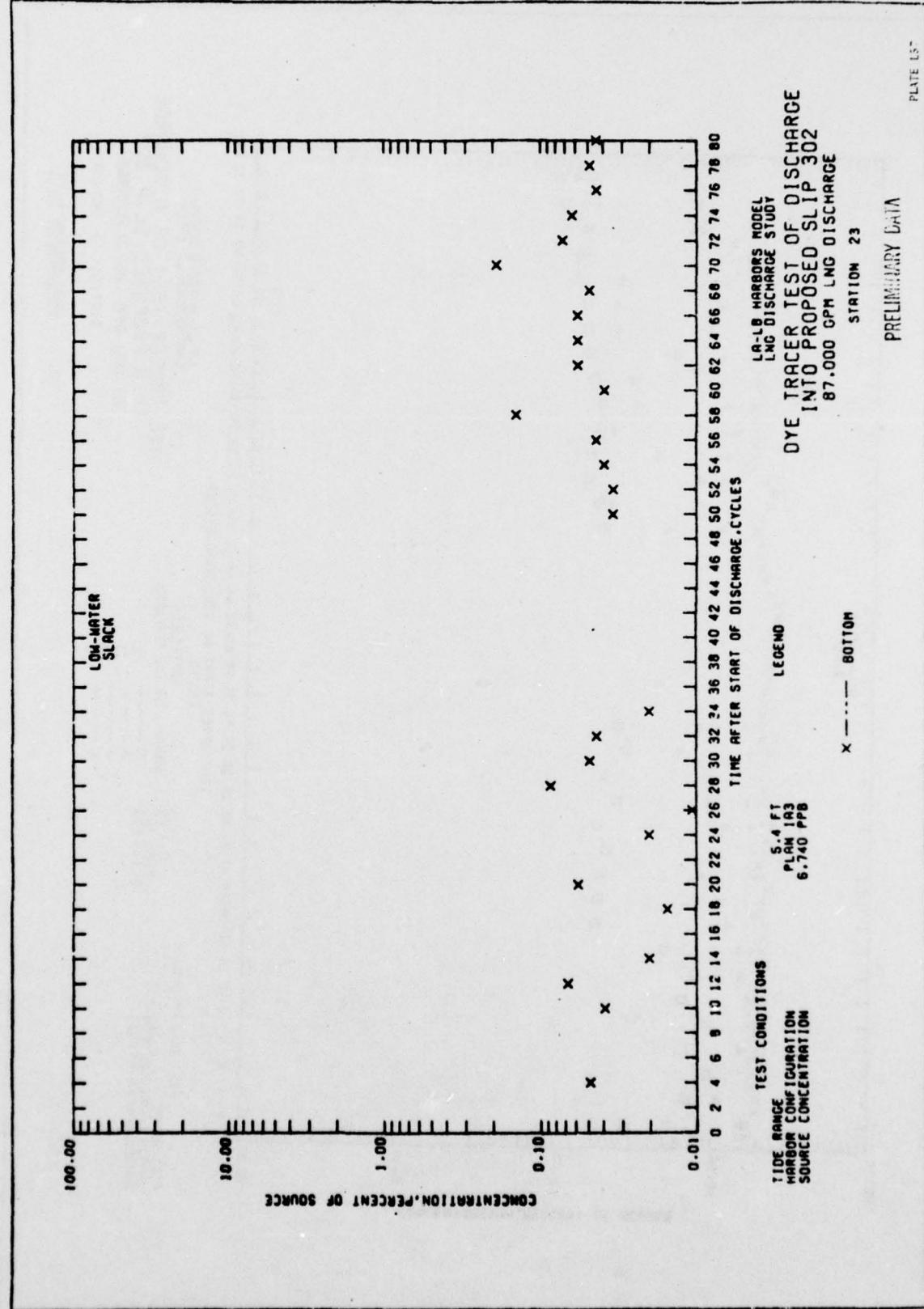


PLATE 1a

PRELIMINARY DATA



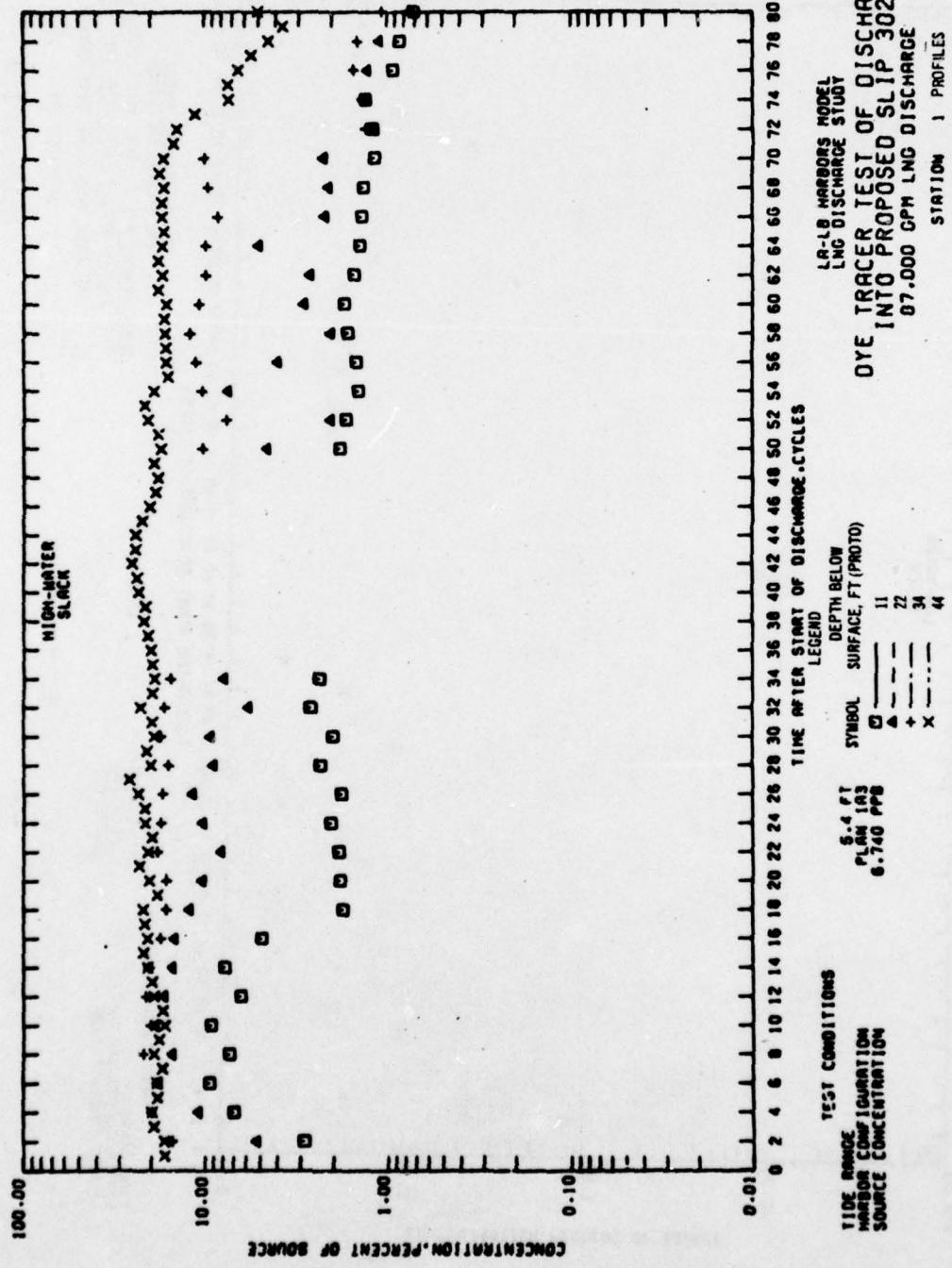


PLATE L-6

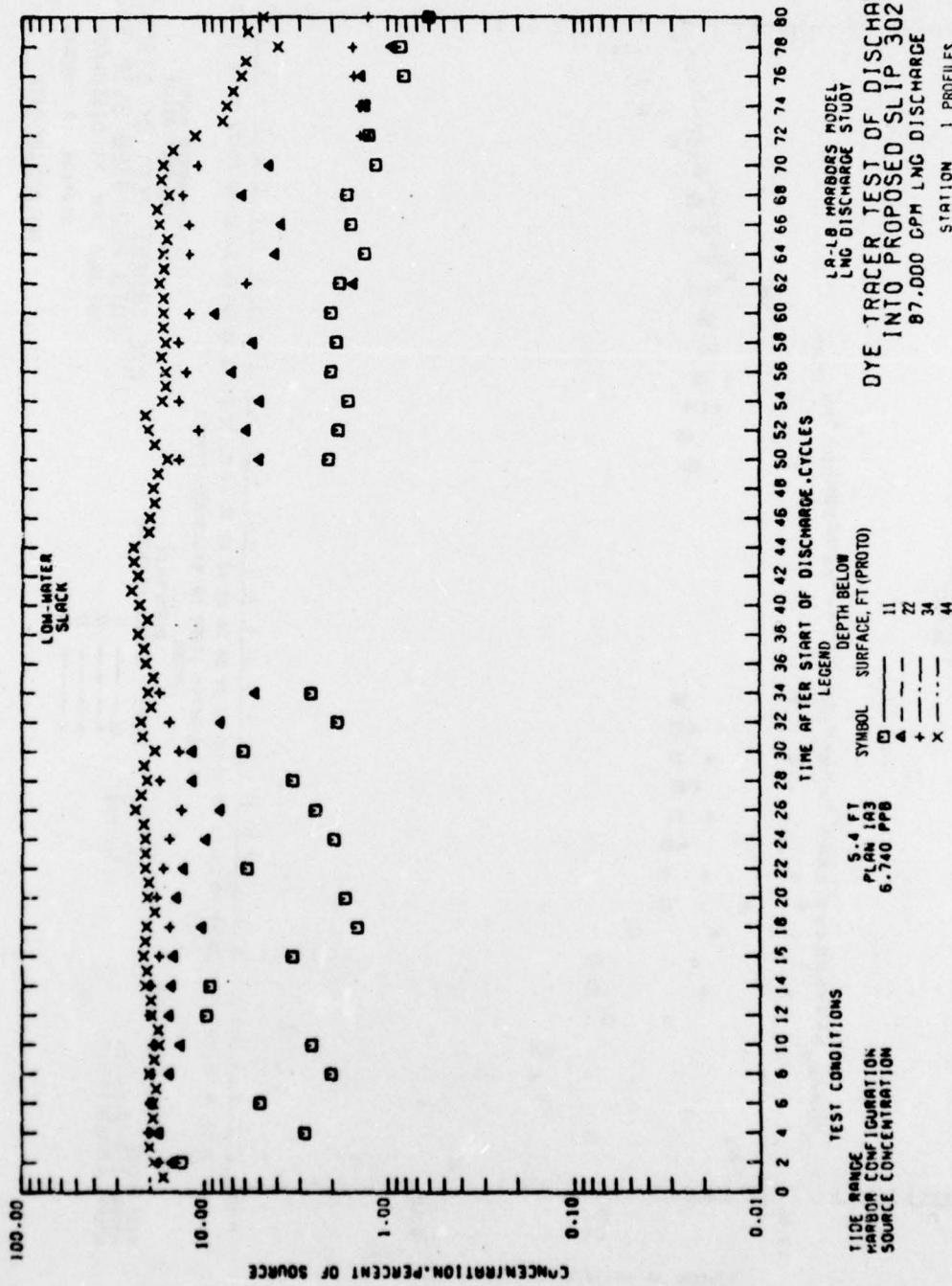


PLATE 1-59

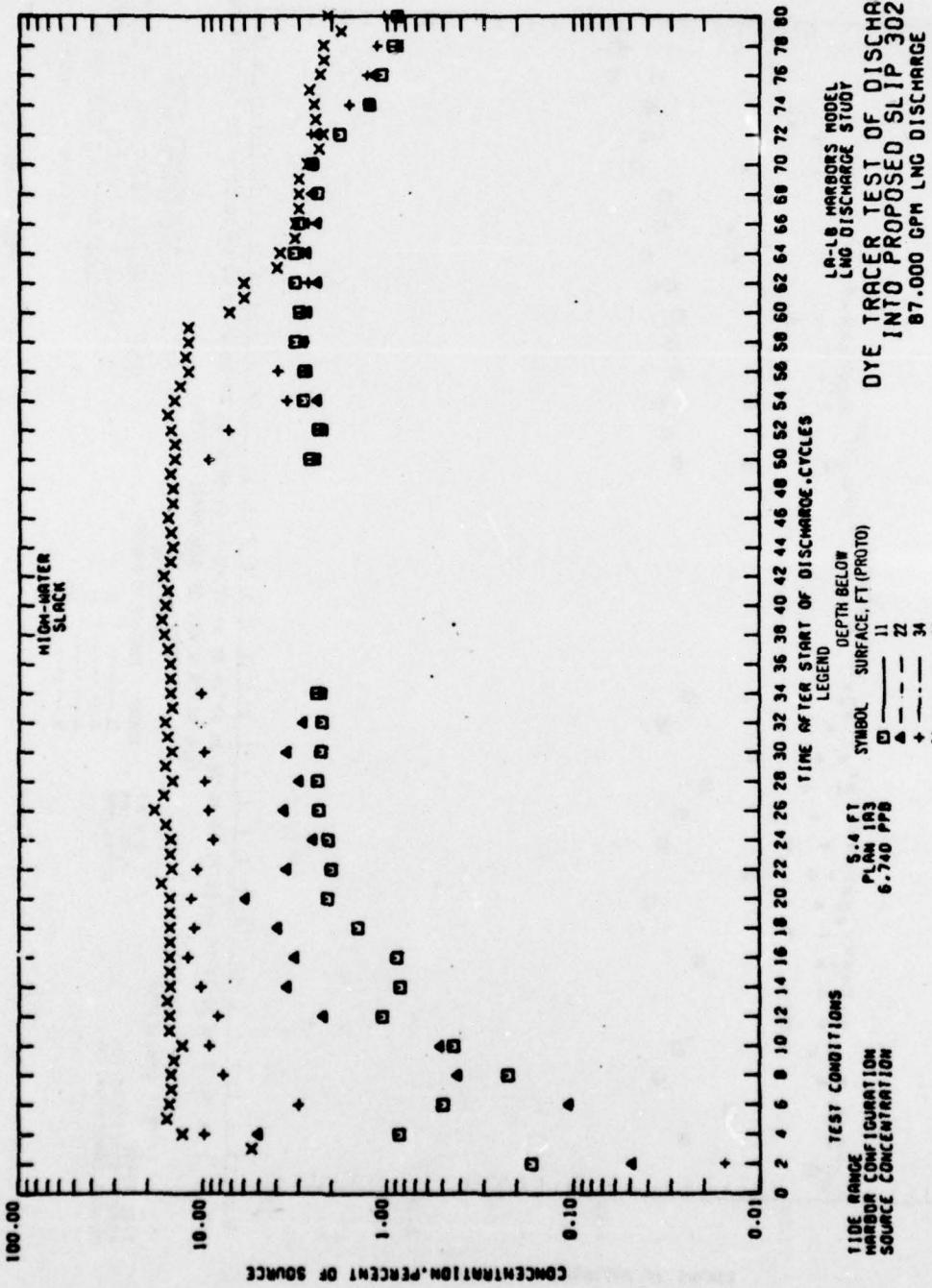
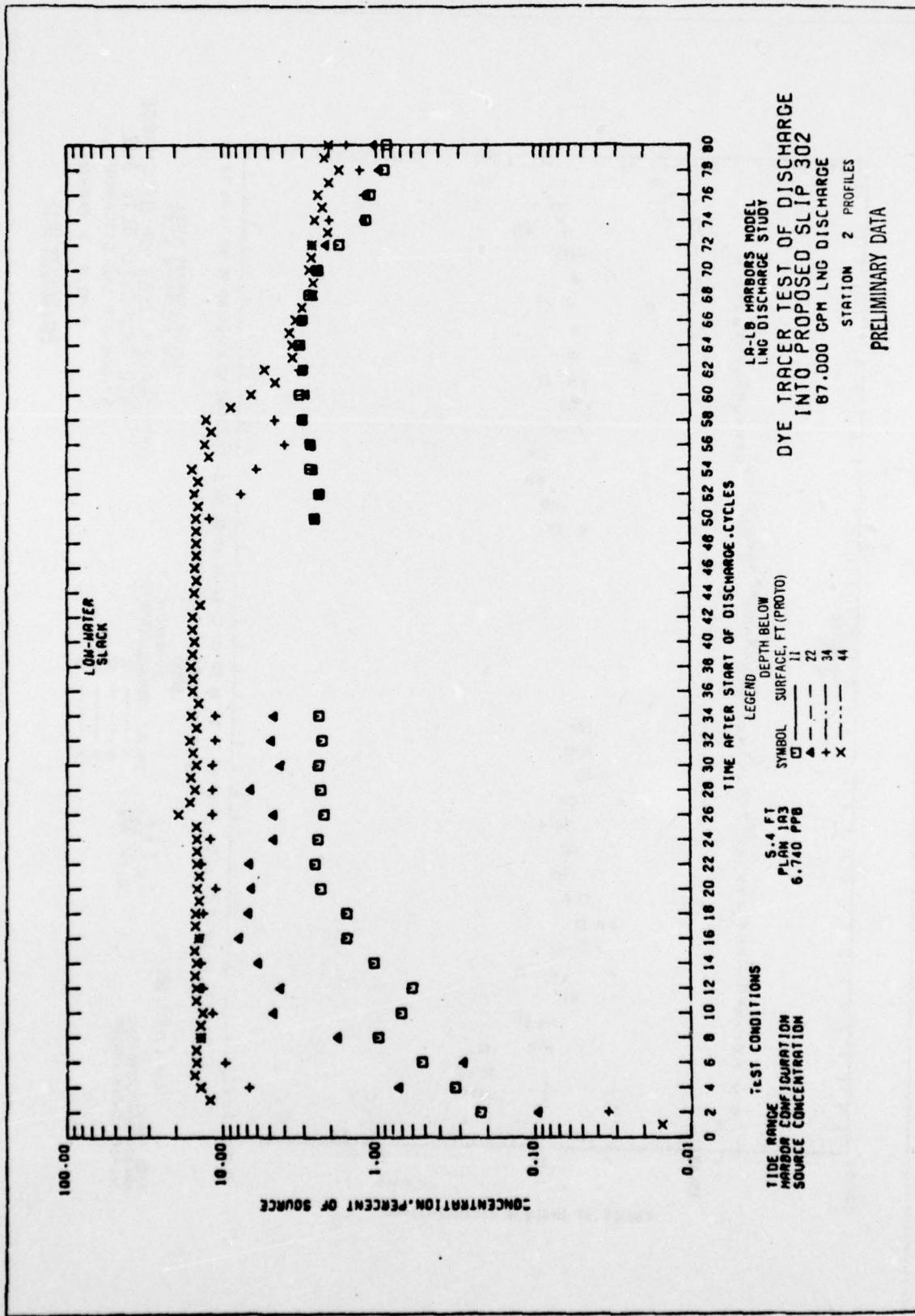


PLATE 6a



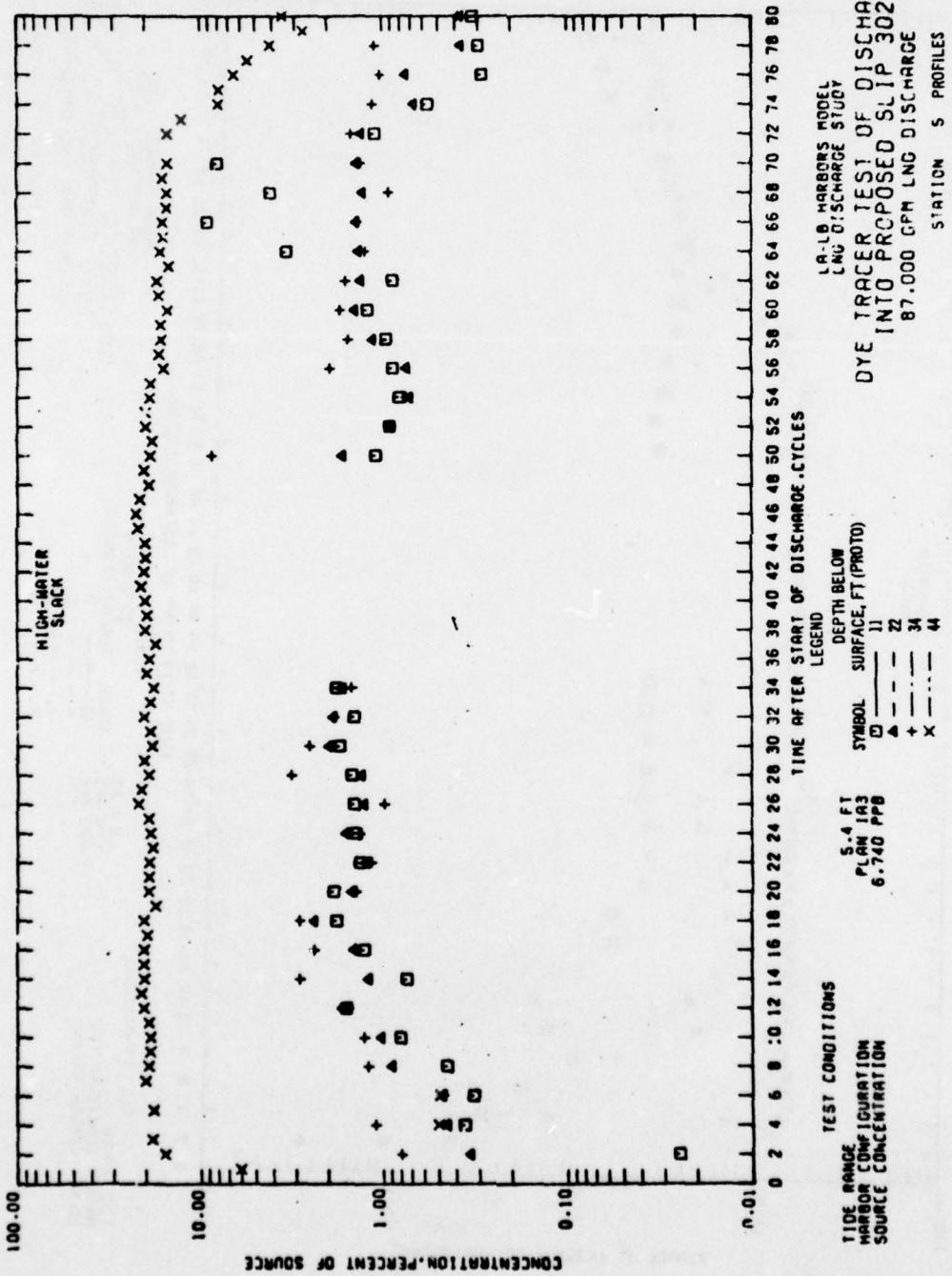
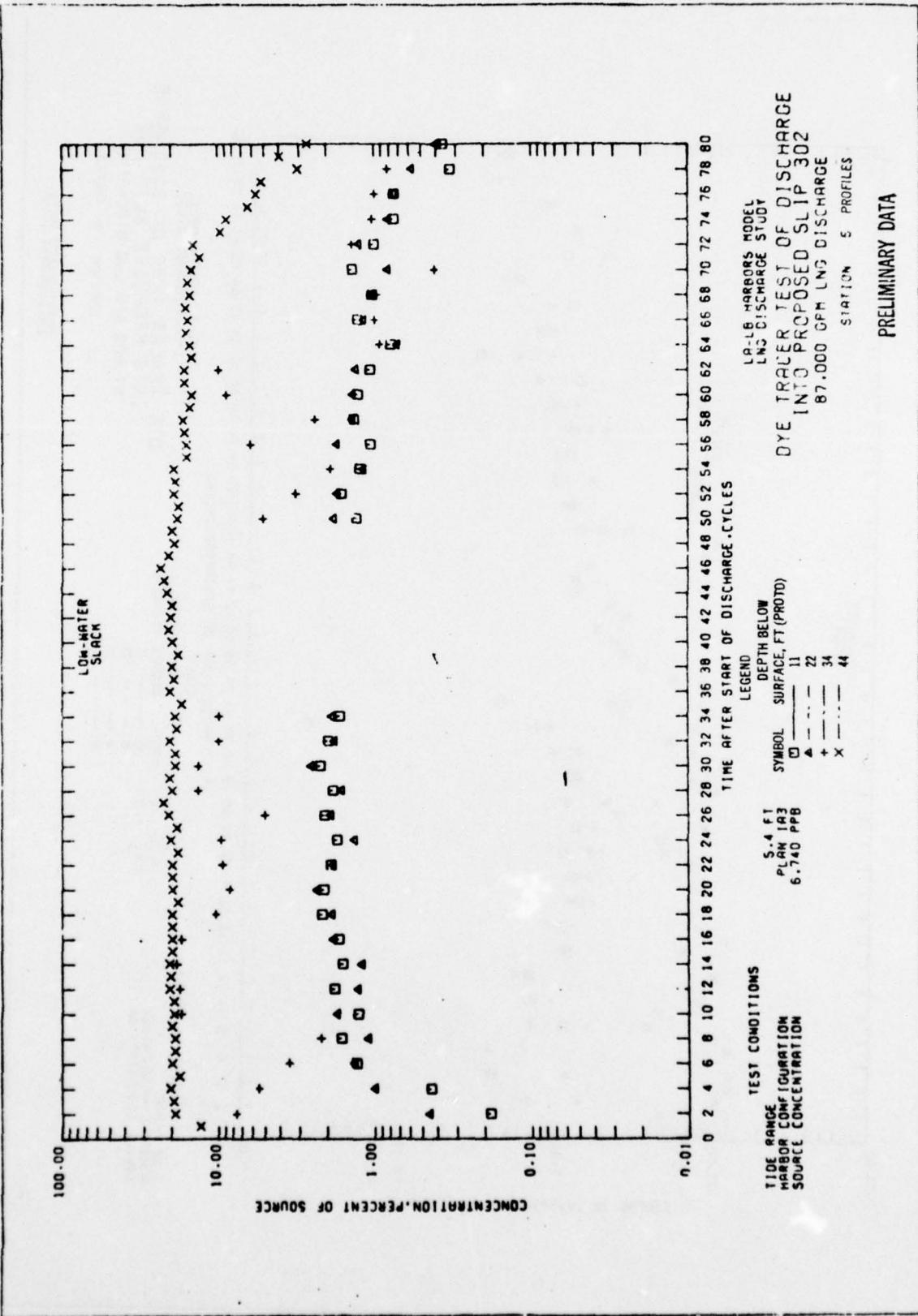
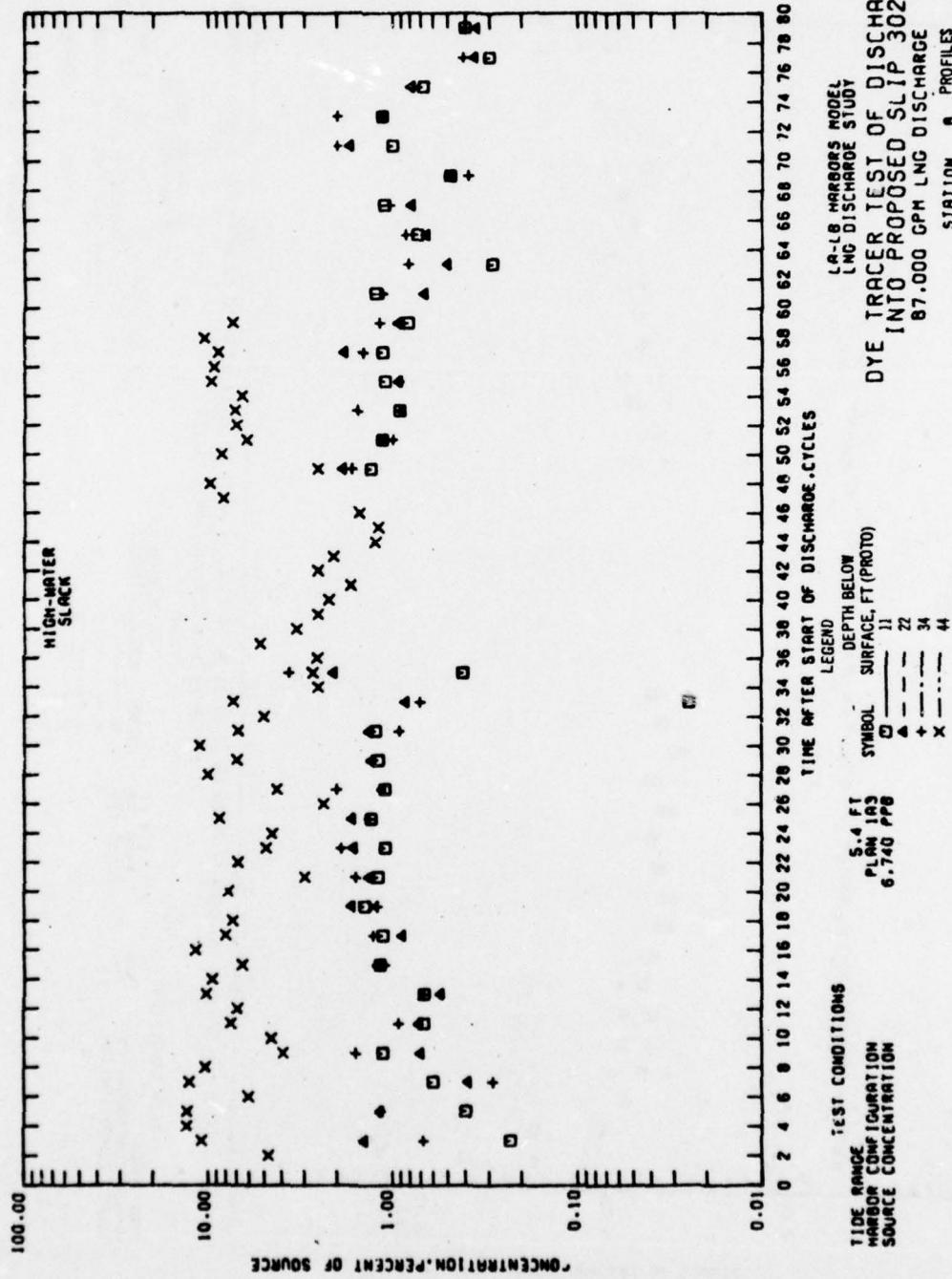
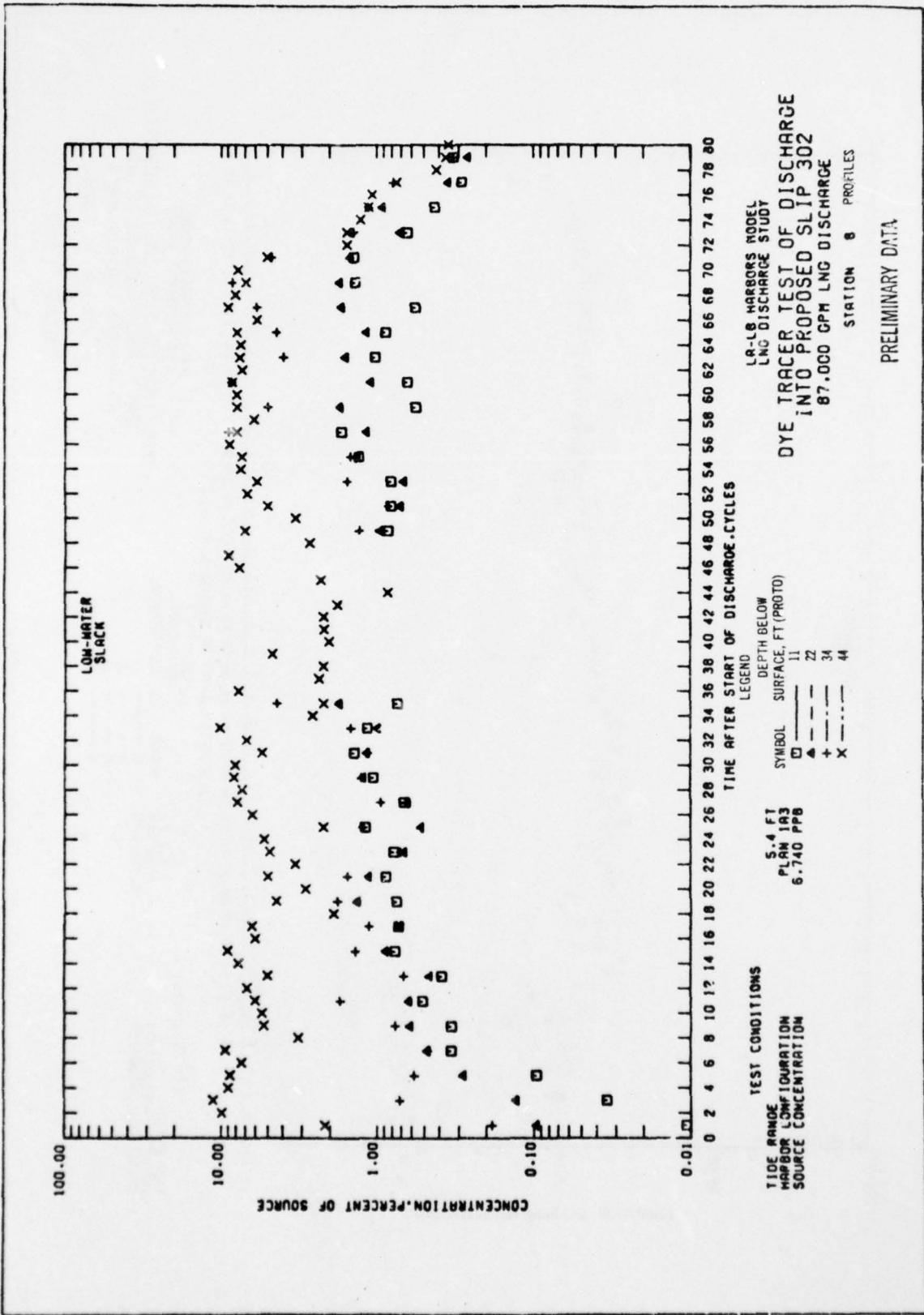
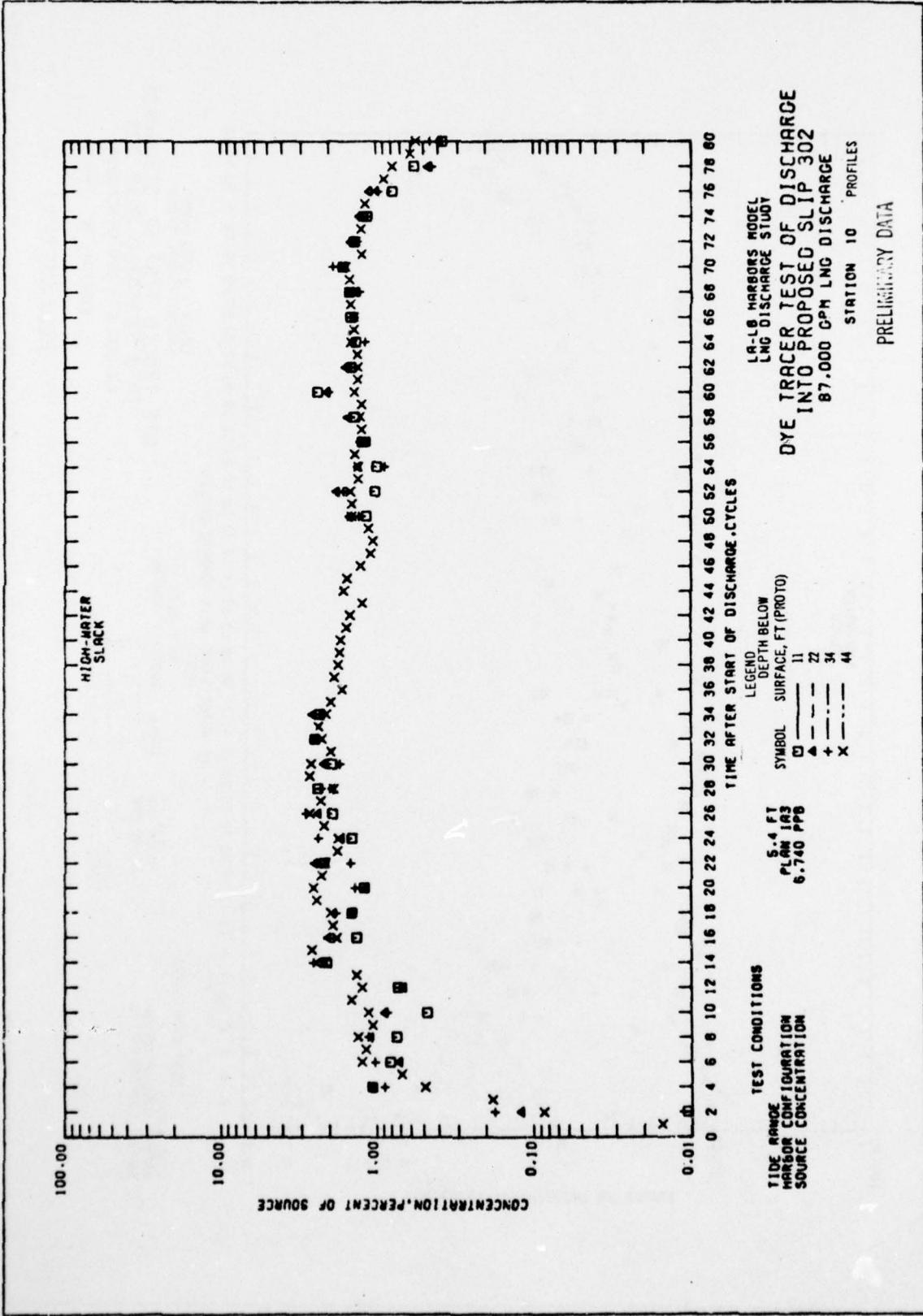


PLATE Lc2









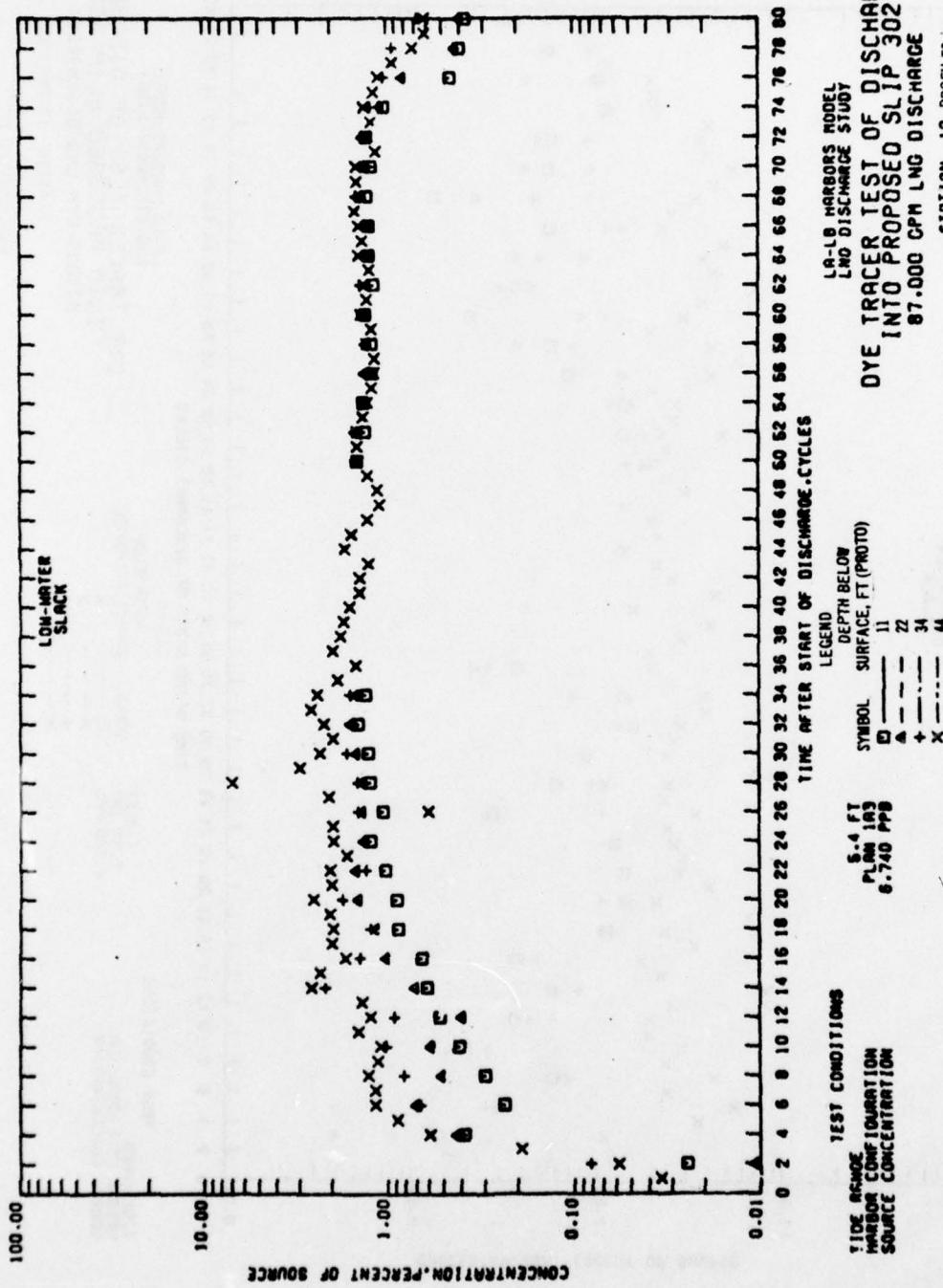
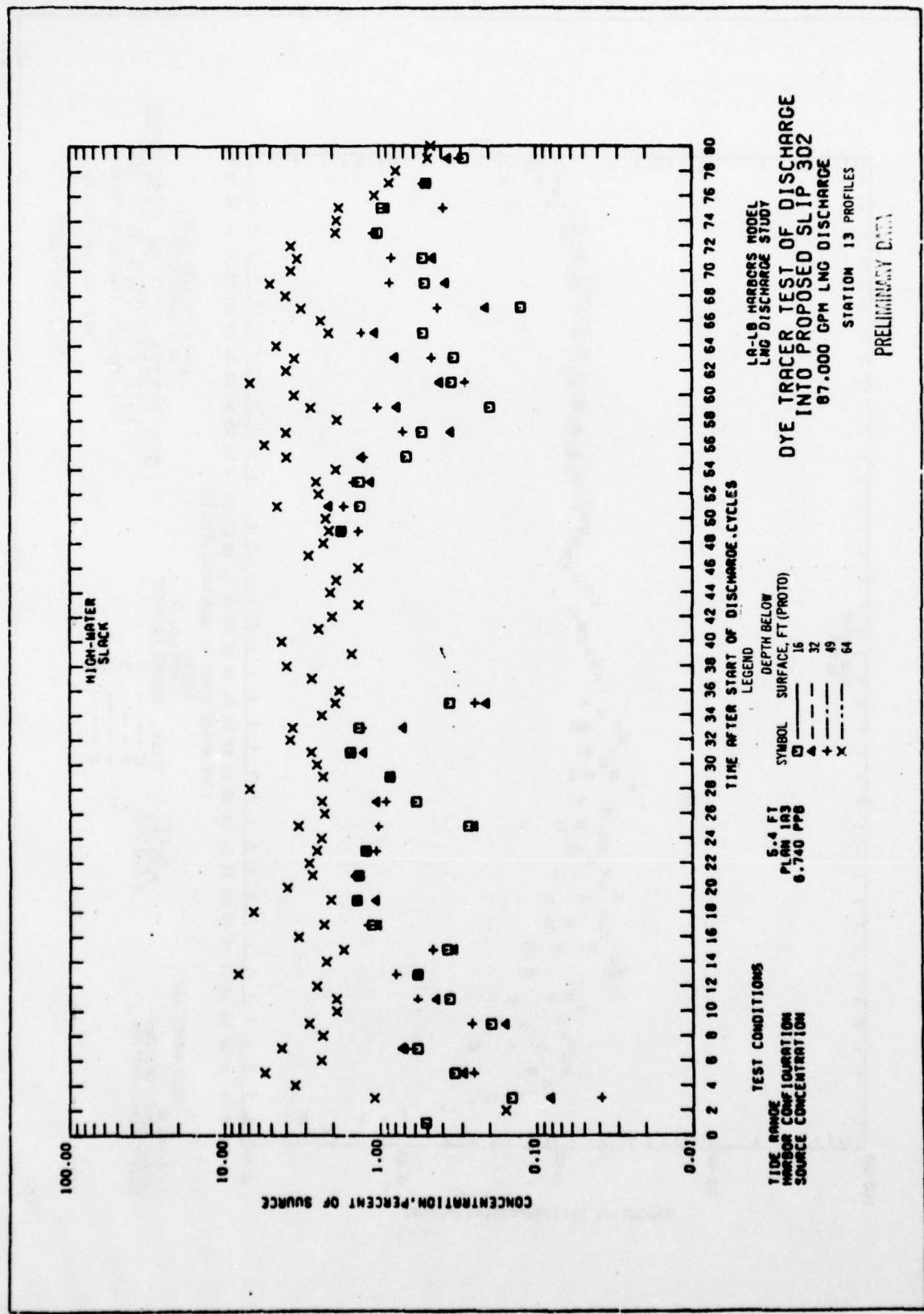
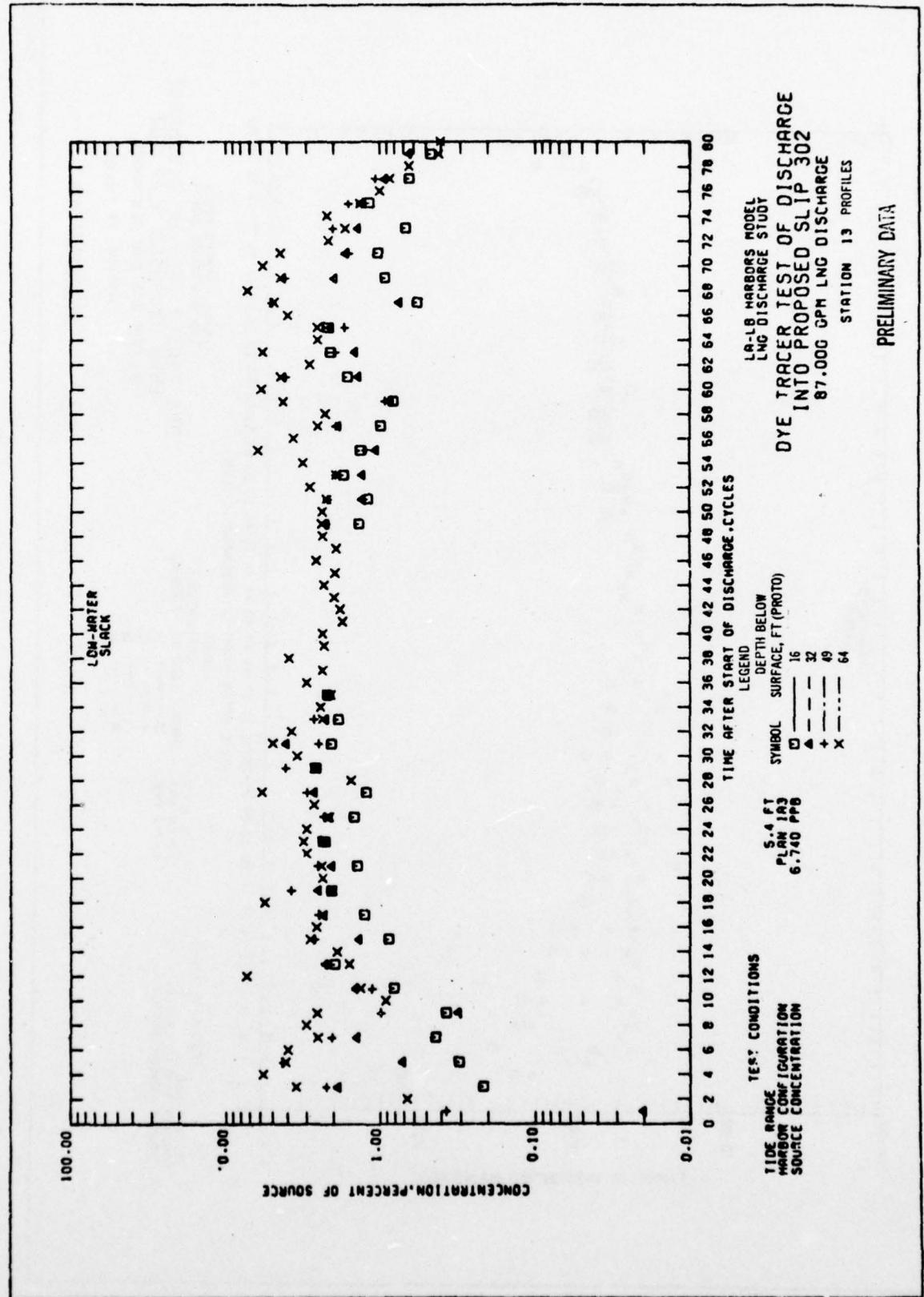


PLATE L67





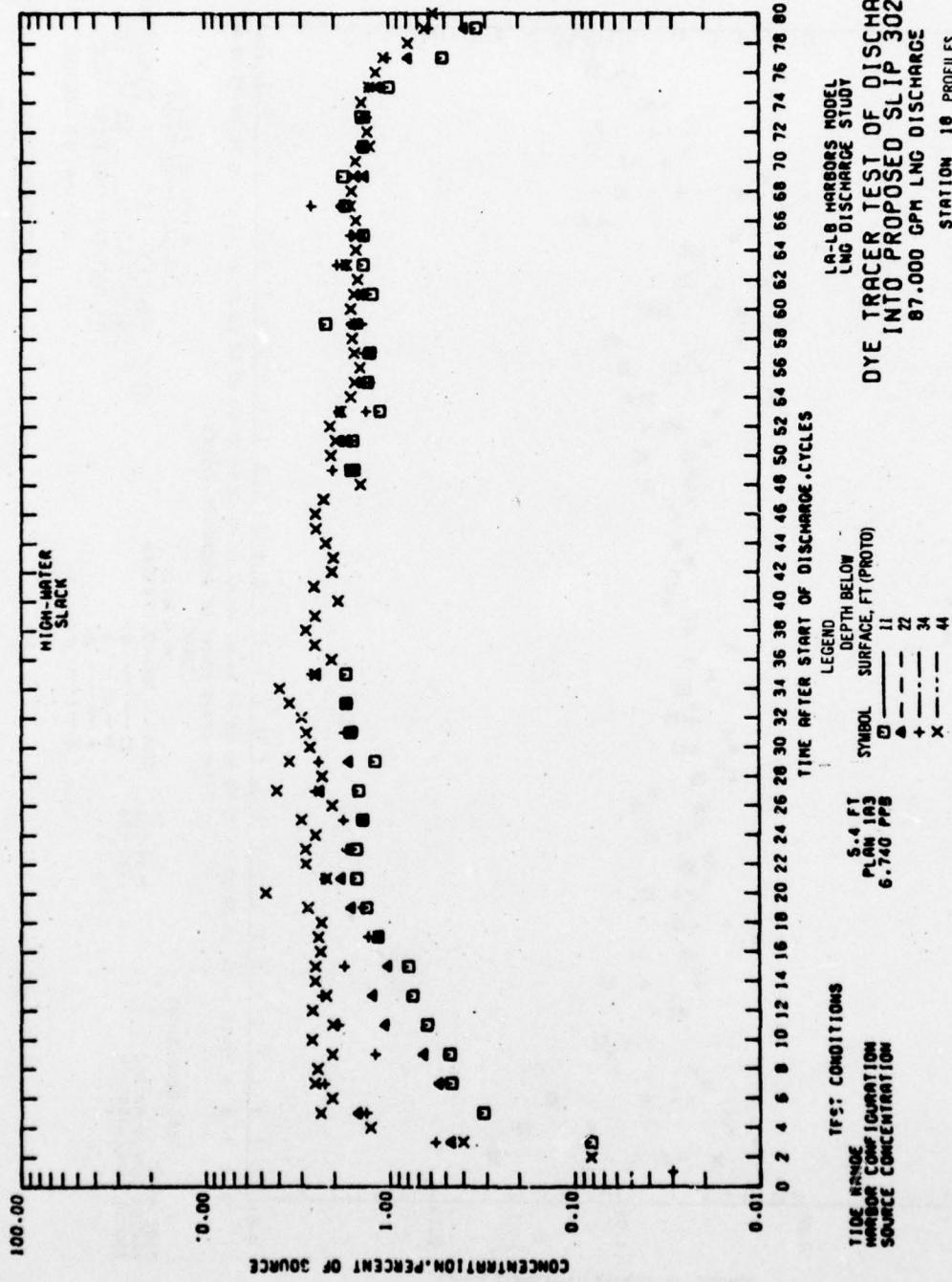
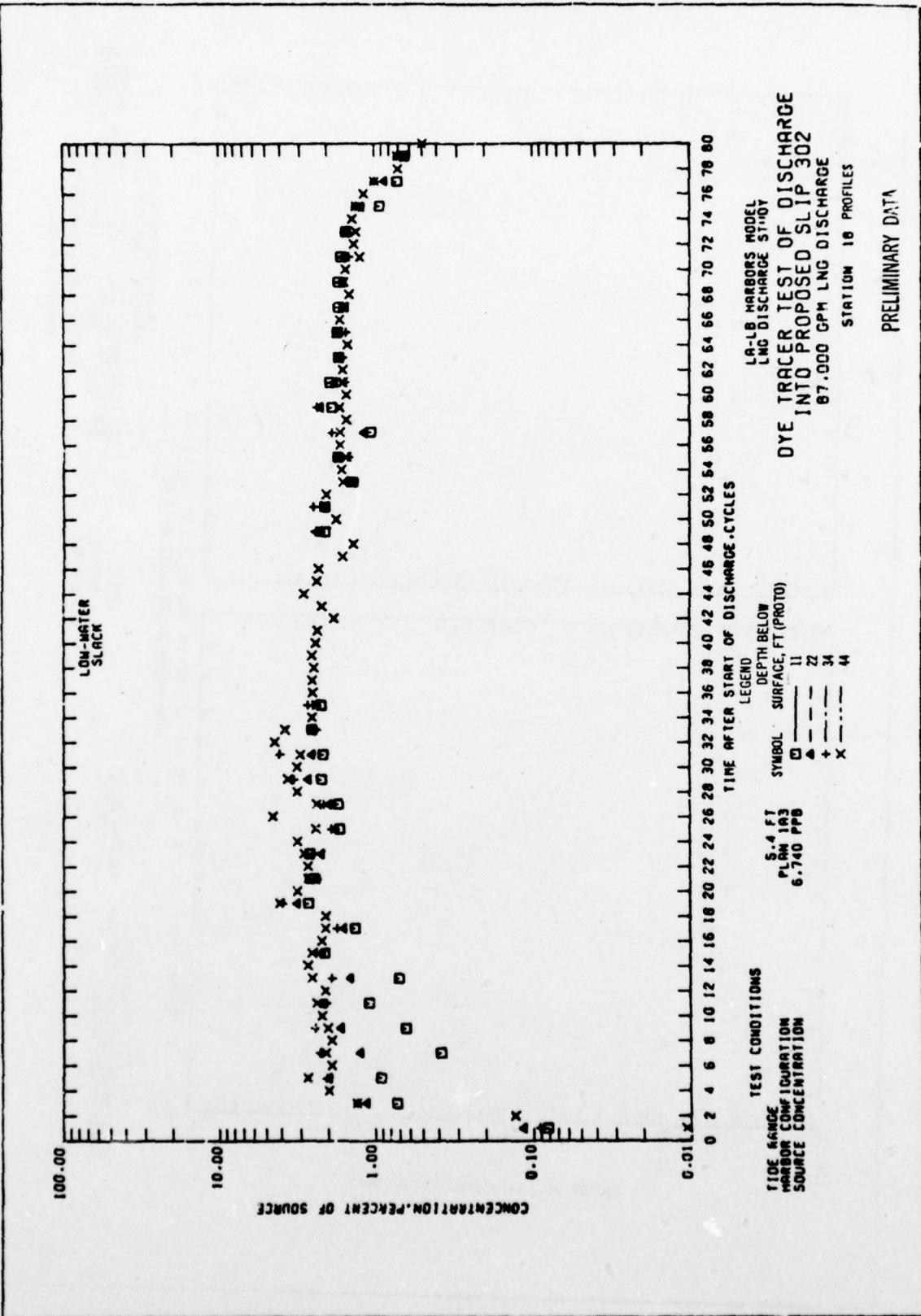
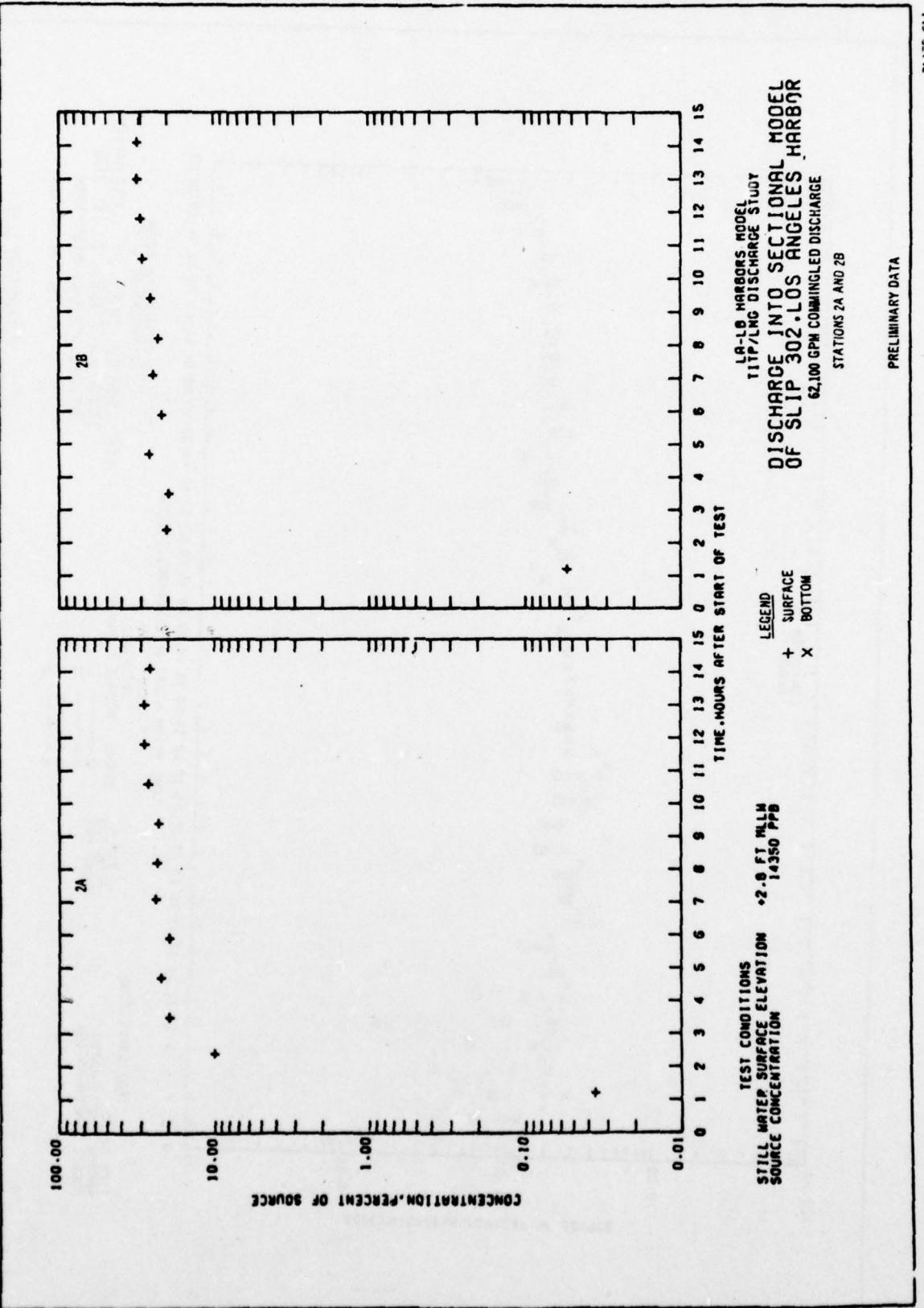
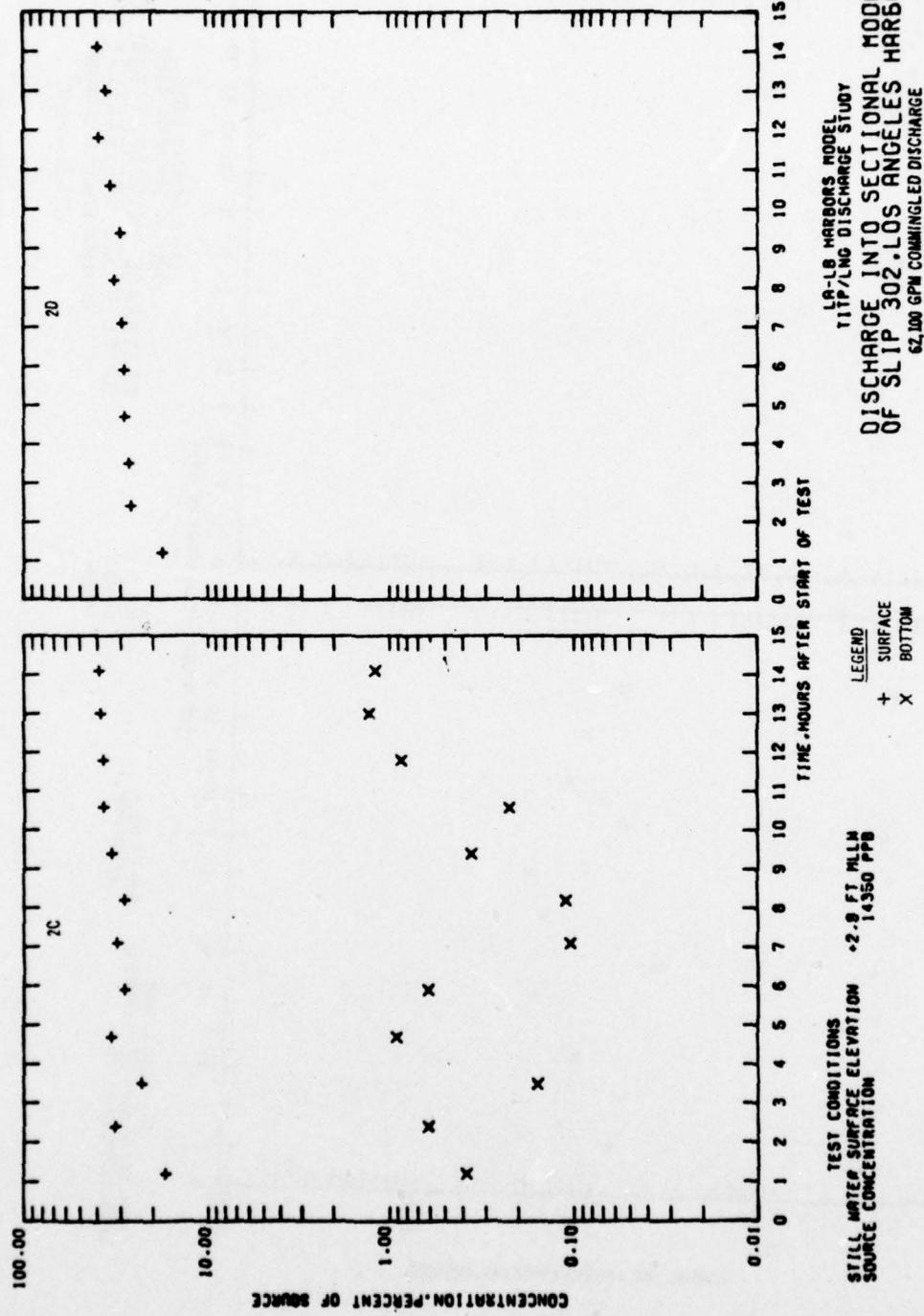


PLATE L-7



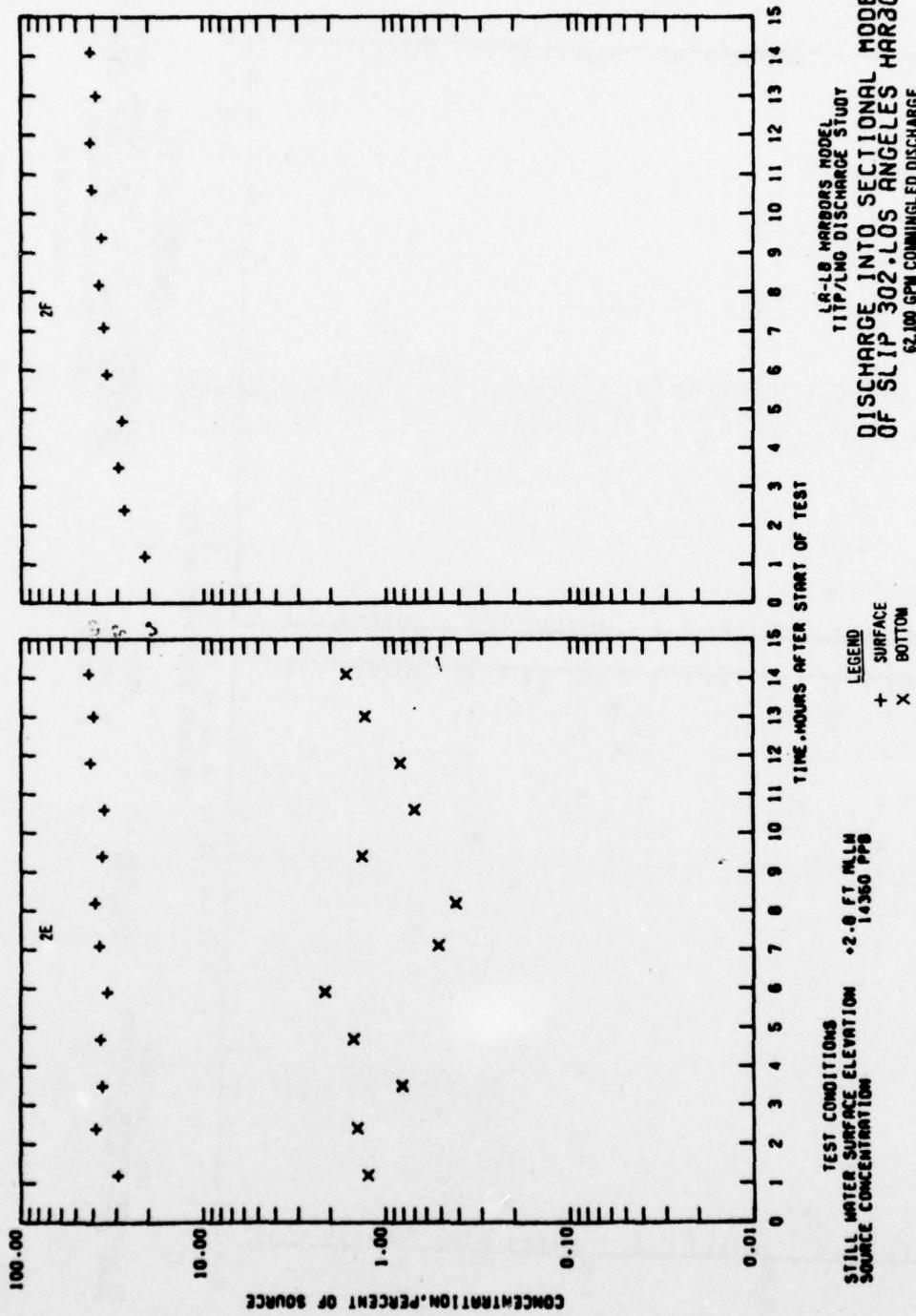




LA-LB HARBOUR MODEL
TIP/LNG DISCHARGE STUDY
DISCHARGE INTO SECTIONAL MODEL
OF SLIP 302.LOS ANGELES HARBOUR
62,000 GPM COMMINGLED DISCHARGE
STATIONS 2C AND 2D

PRELIMINARY DATA

PLATE 4



PRELIMINARY DATA

PLATE S1.5

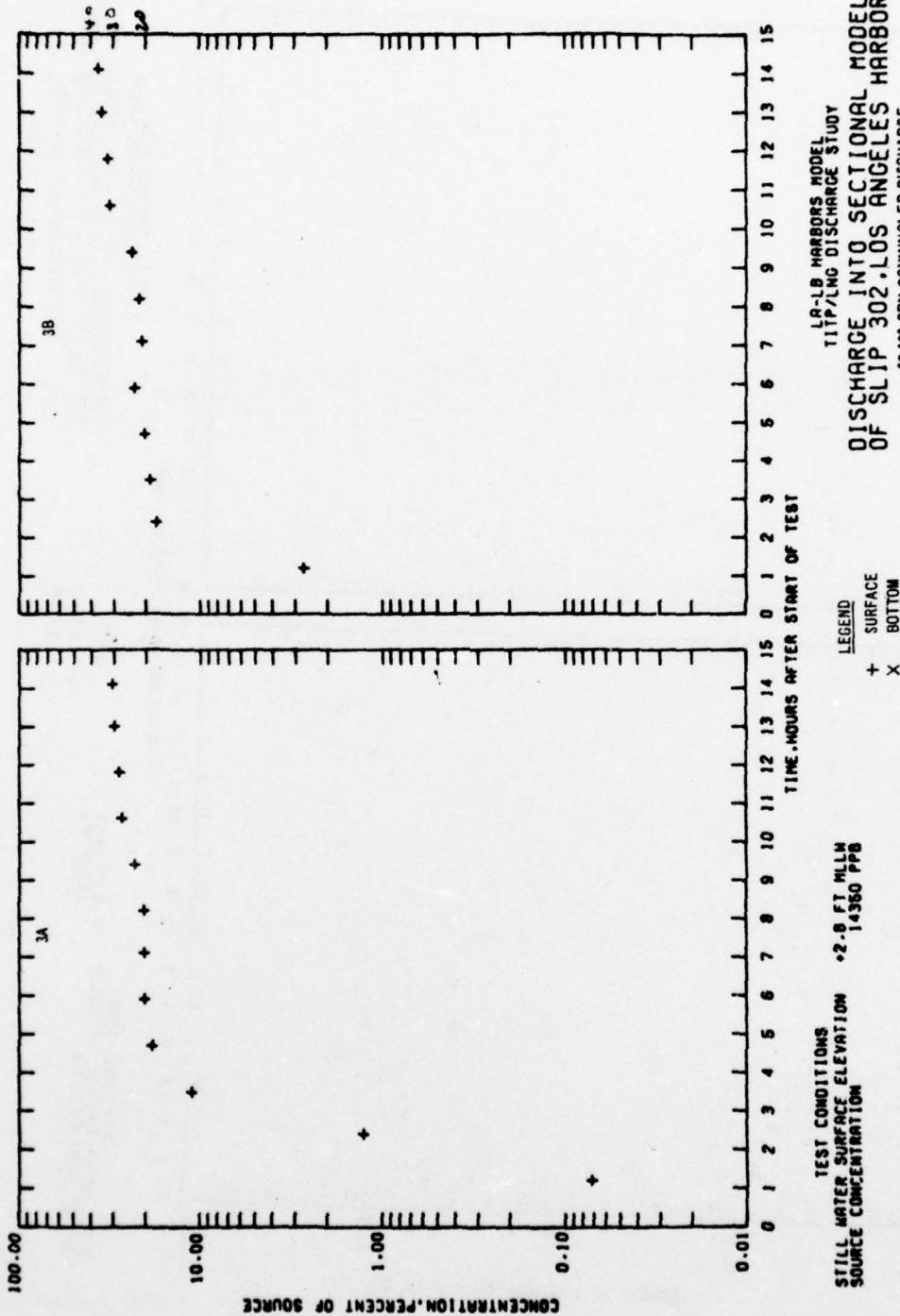
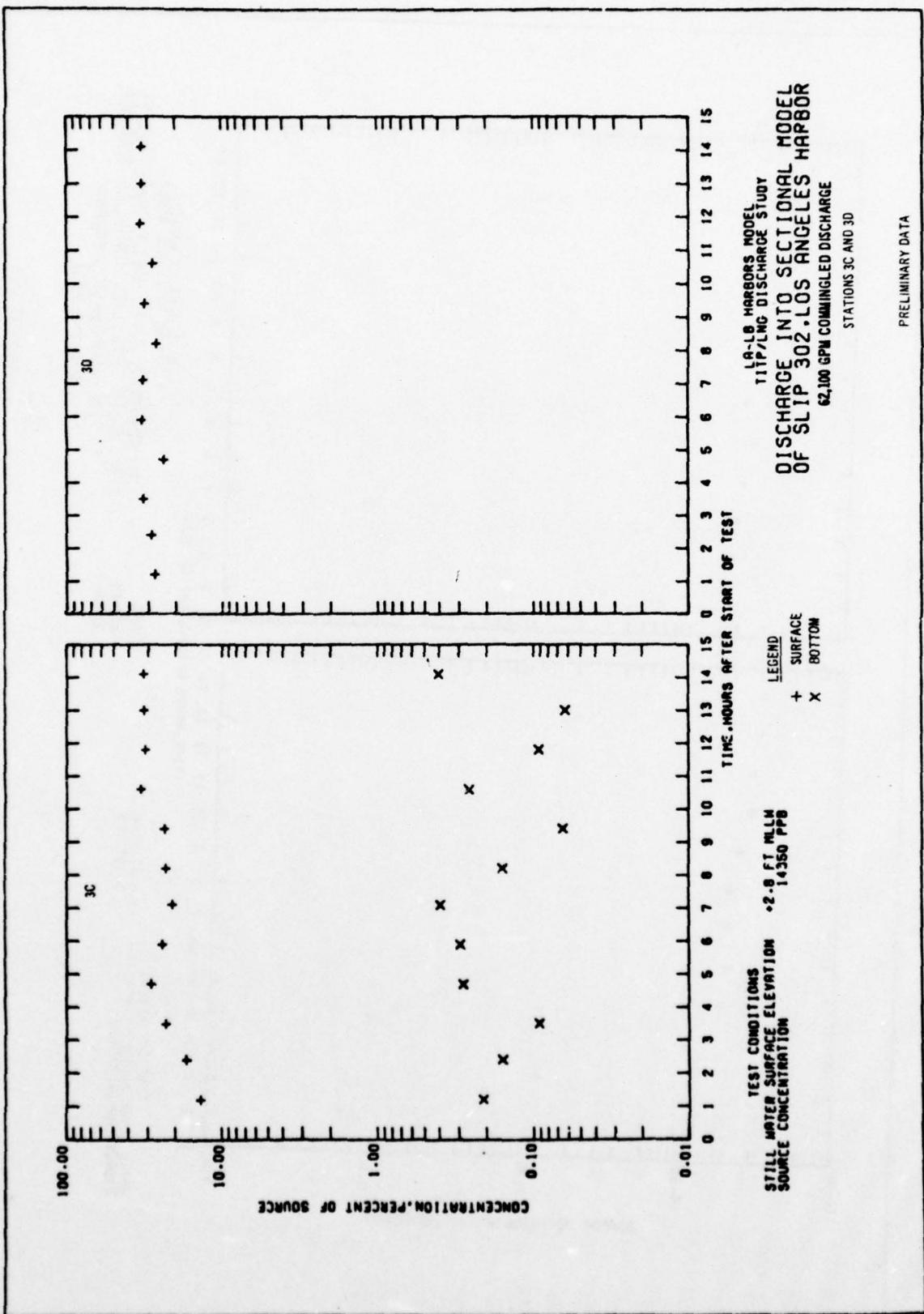
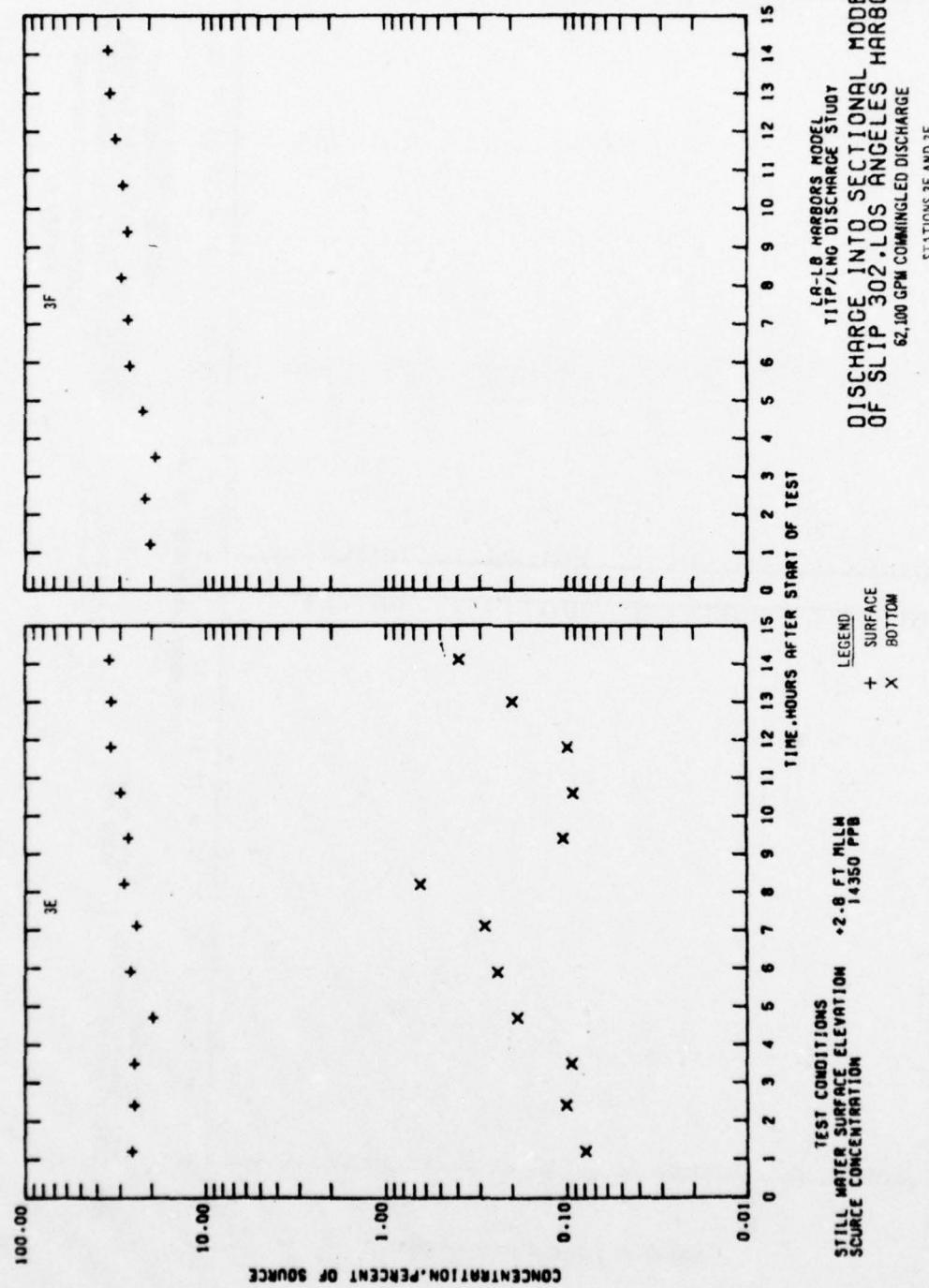


PLATE 54





PRELIMINARY DATA

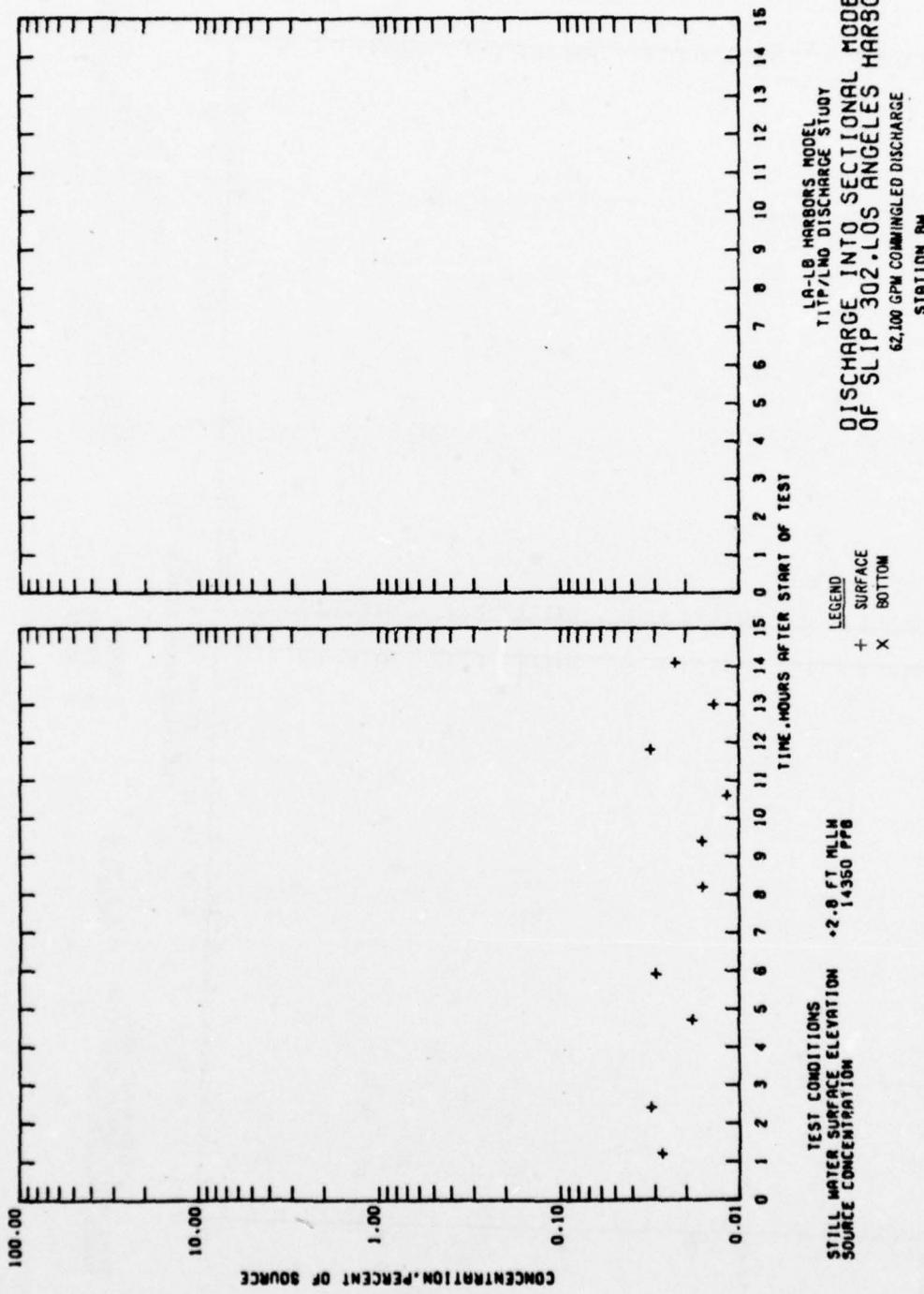
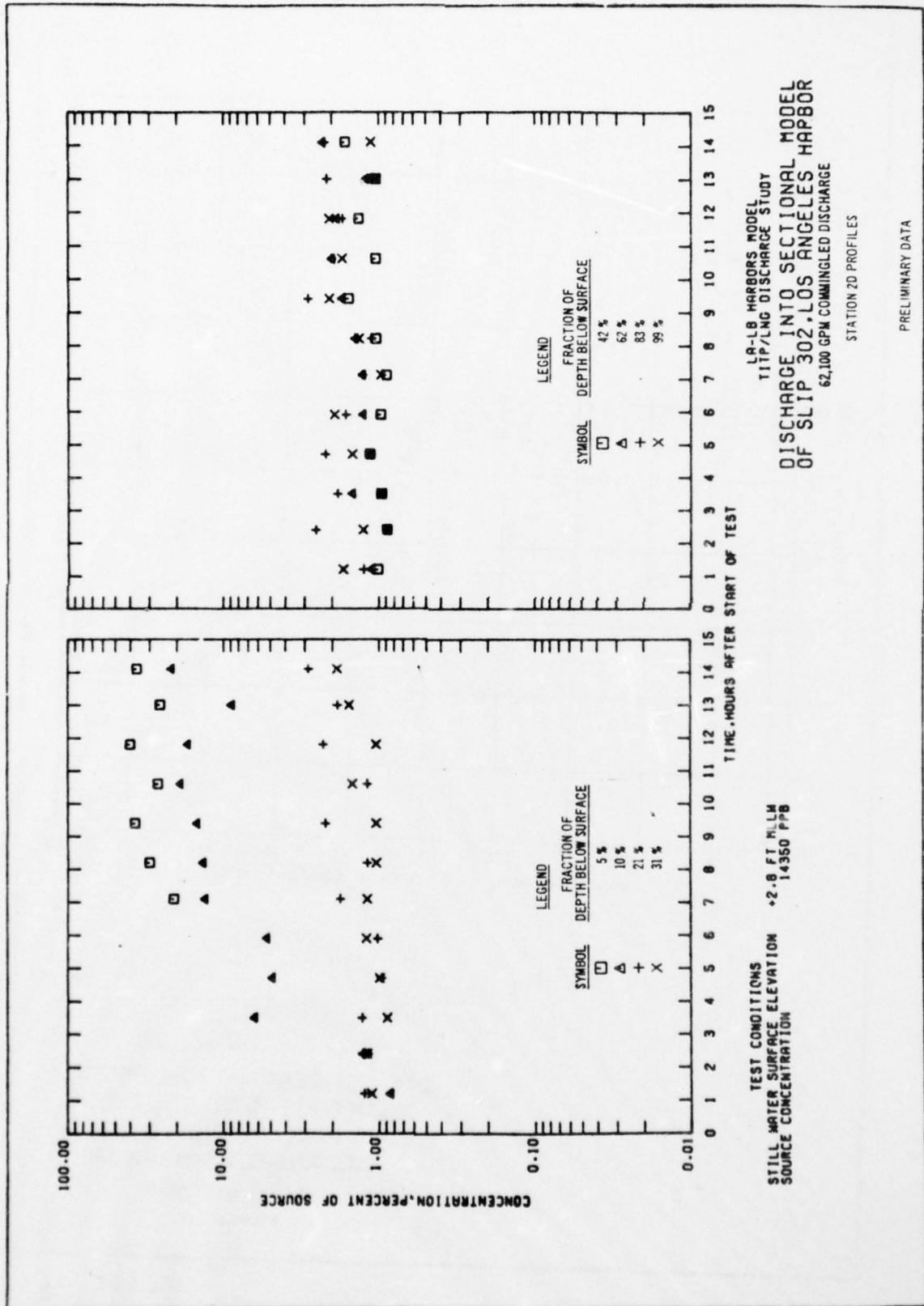
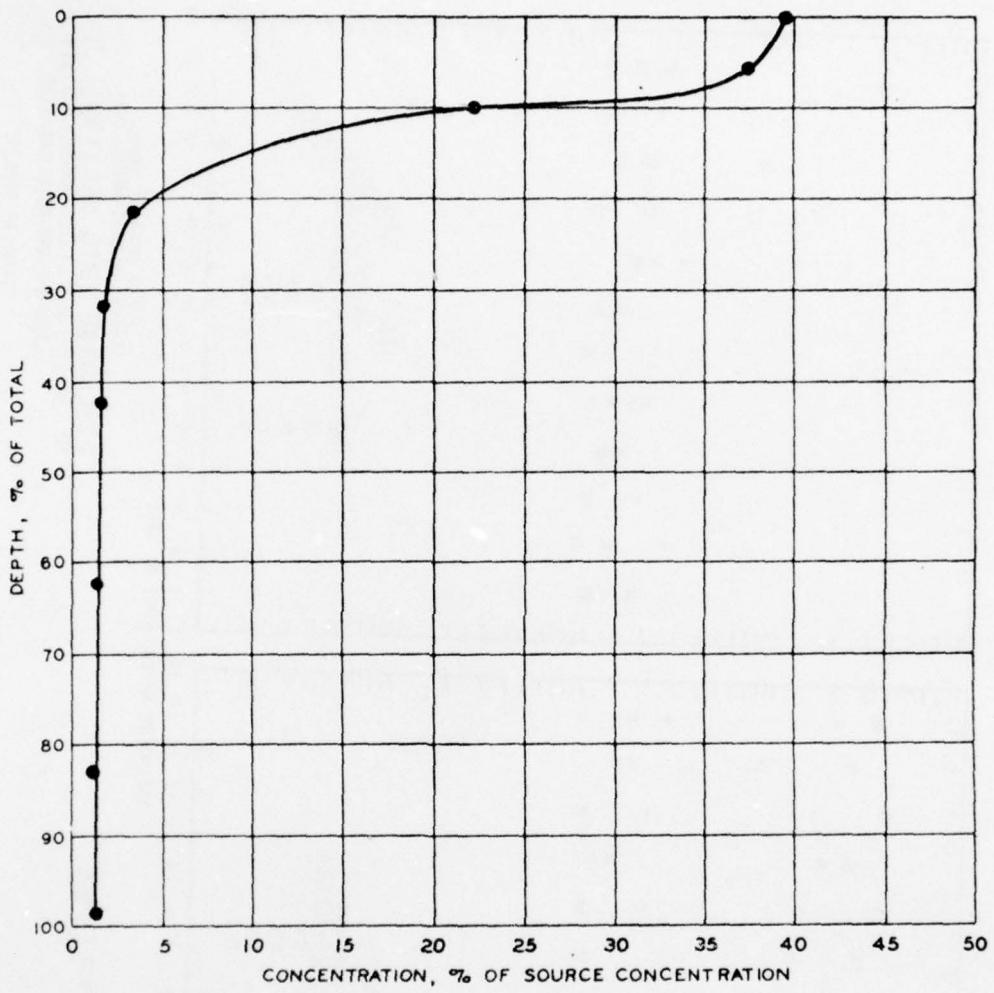


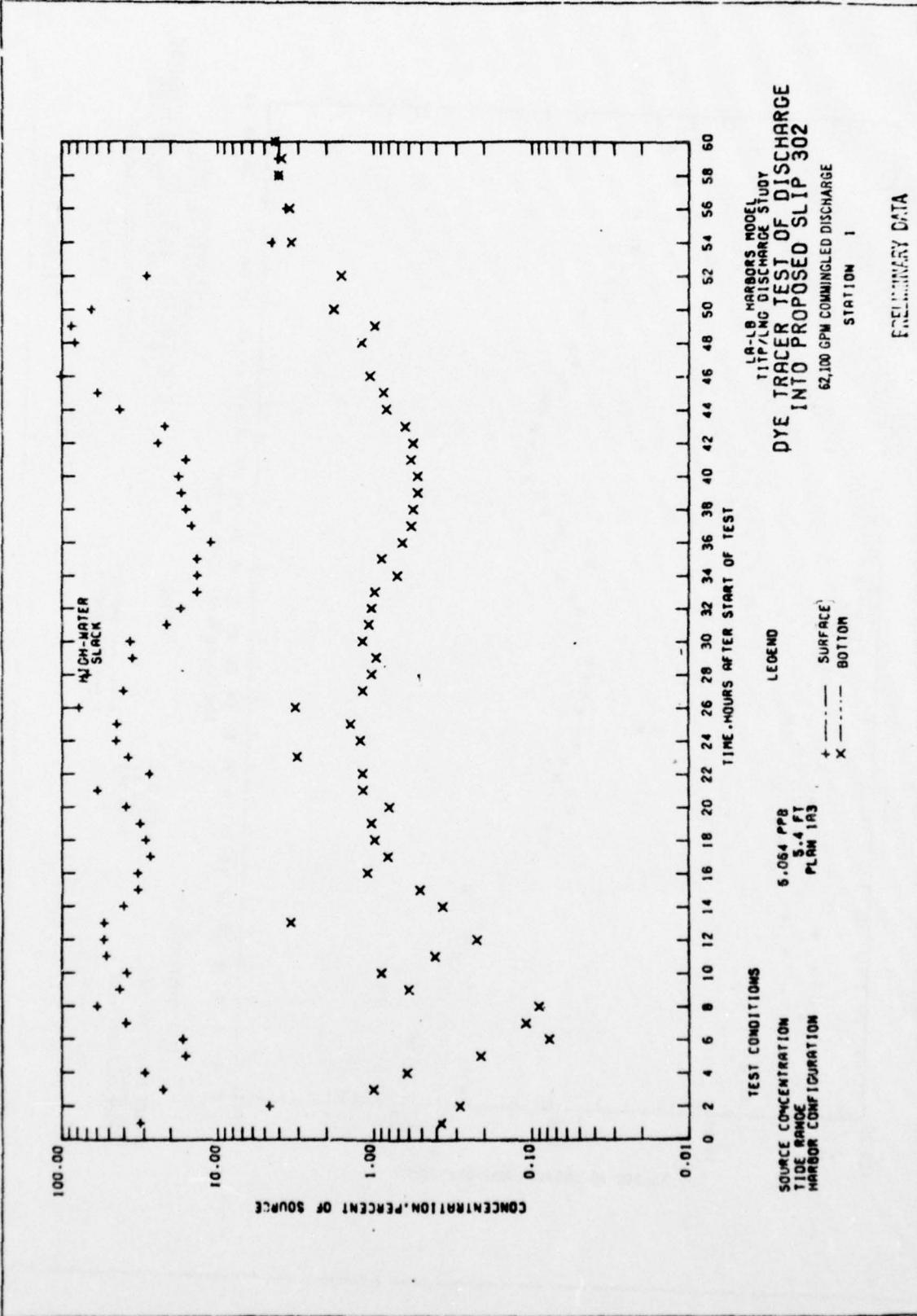
PLATE 54

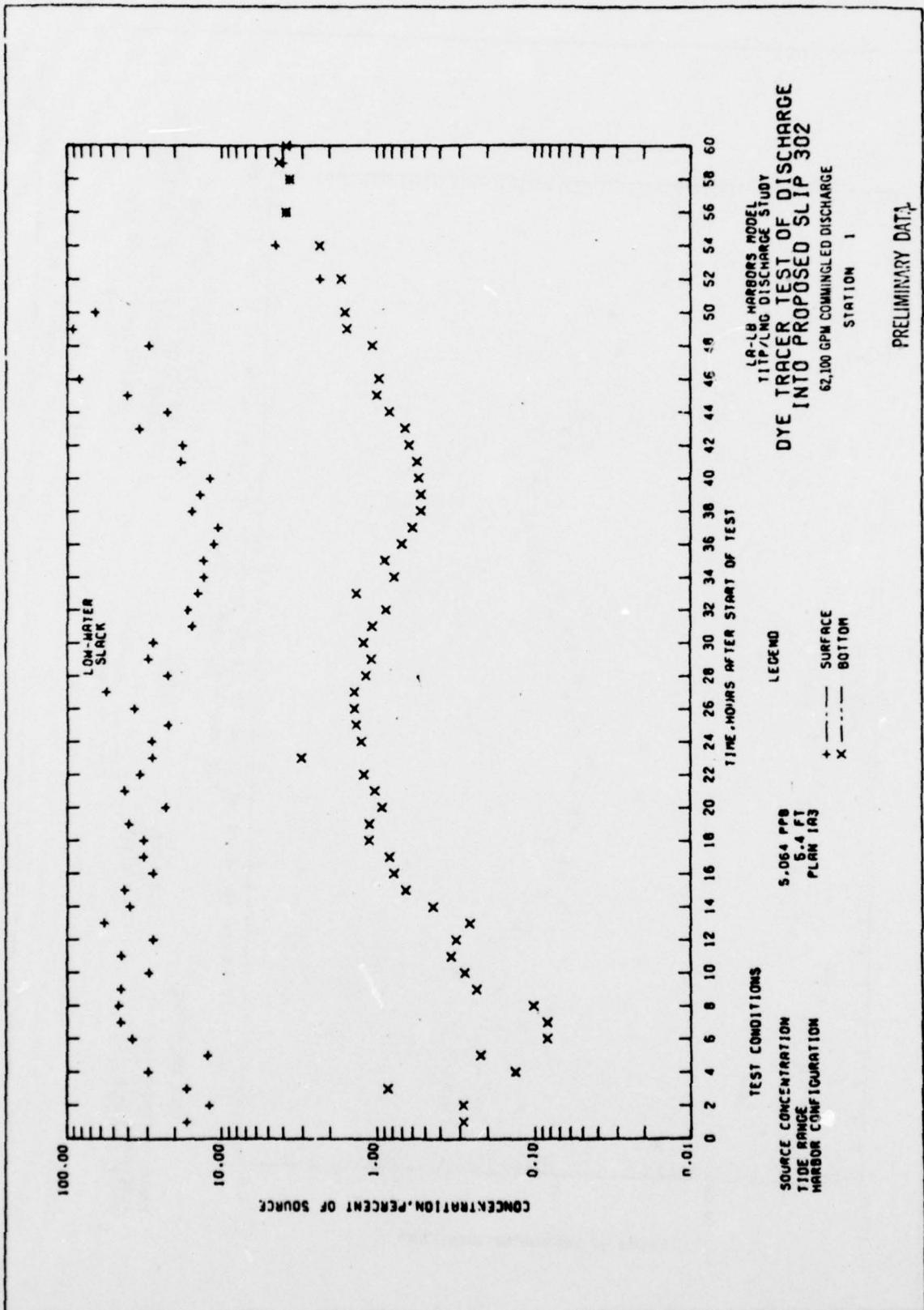


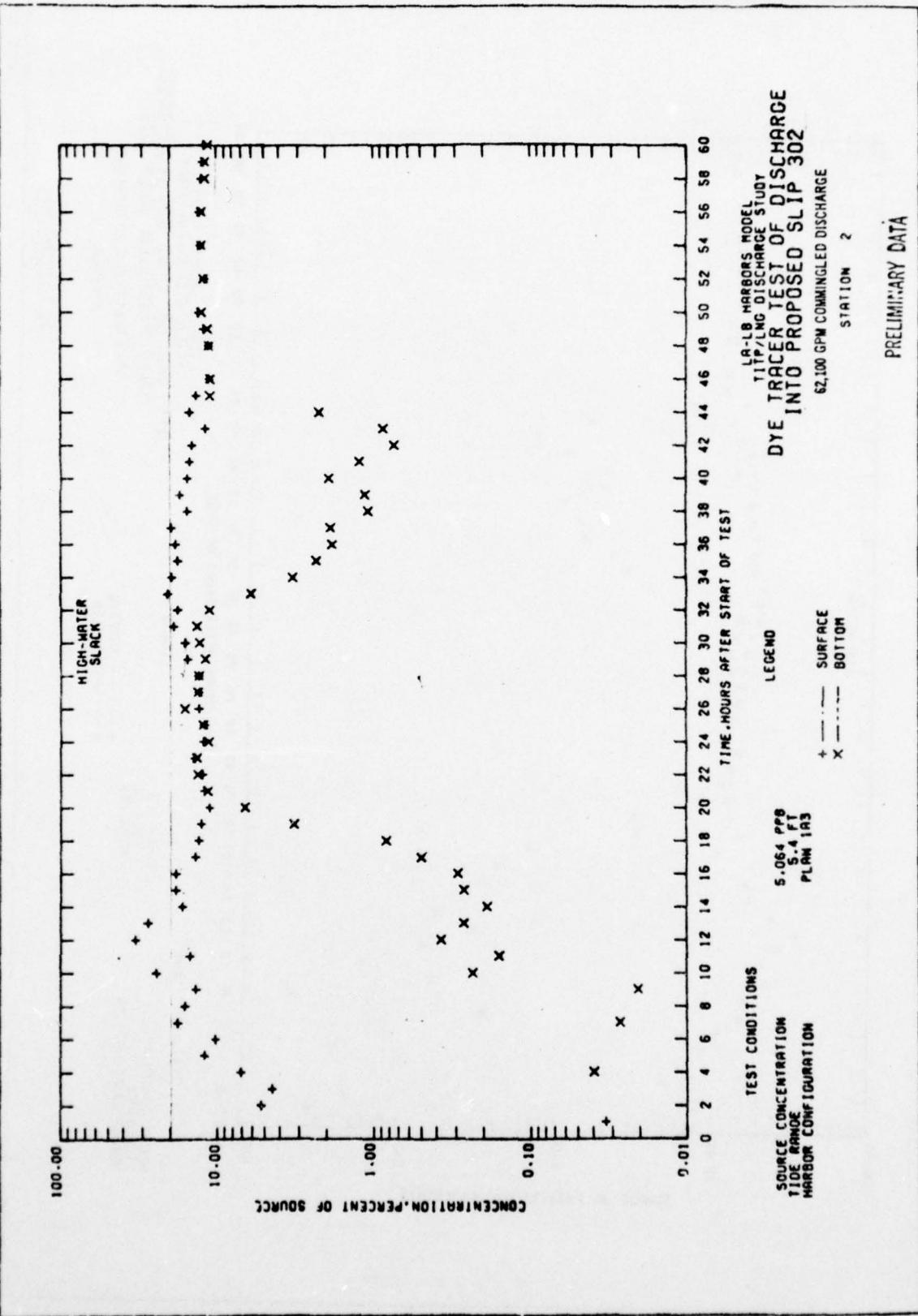


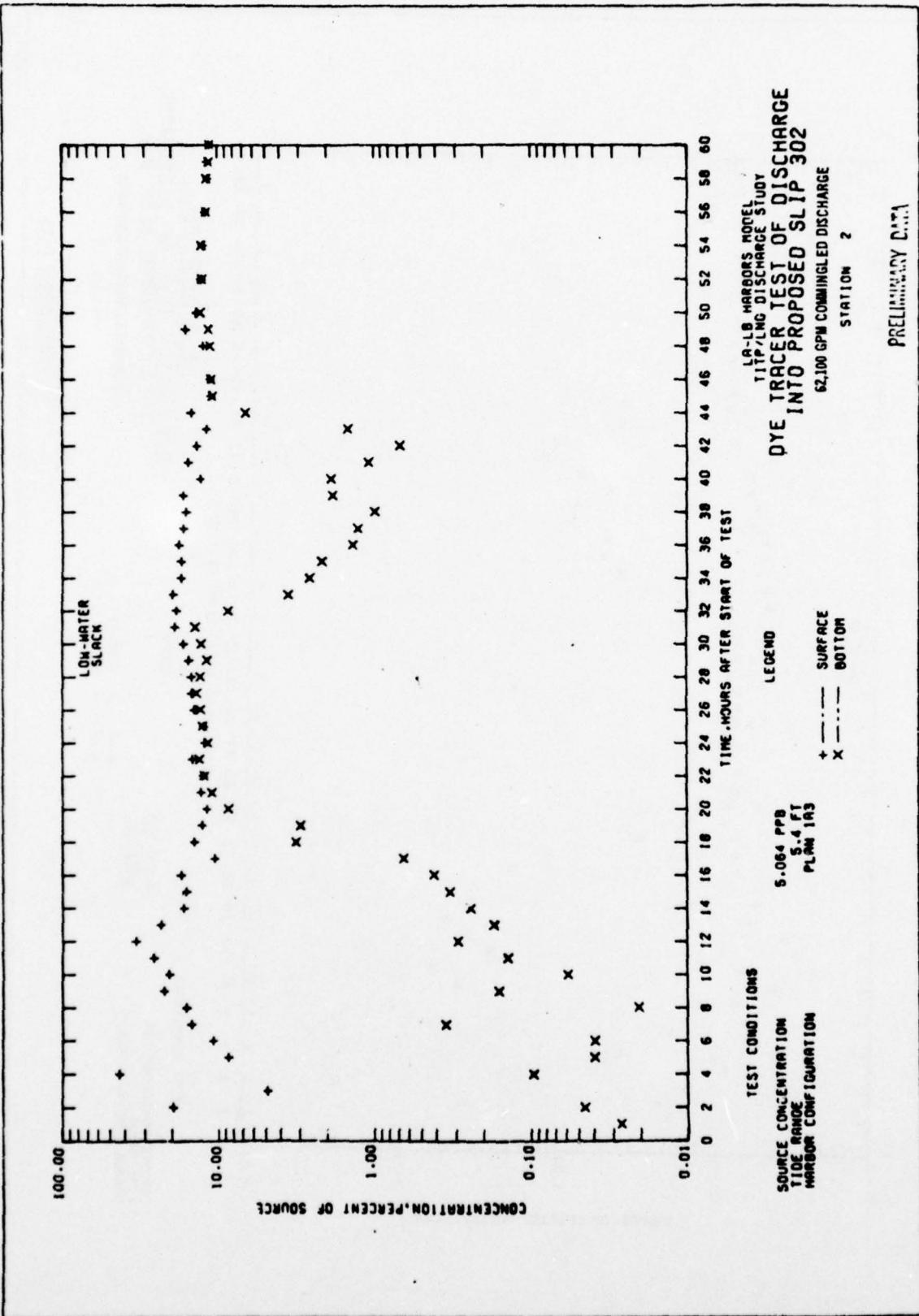
LA - LB HARBORS MODEL
DYE CONCENTRATION PROFILE
DISCHARGE INTO SECTIONAL
MODEL OF SLIP 302,
LOS ANGELES HARBOR
TEST NO. SM3
STATION 2D

PLATE SL8A









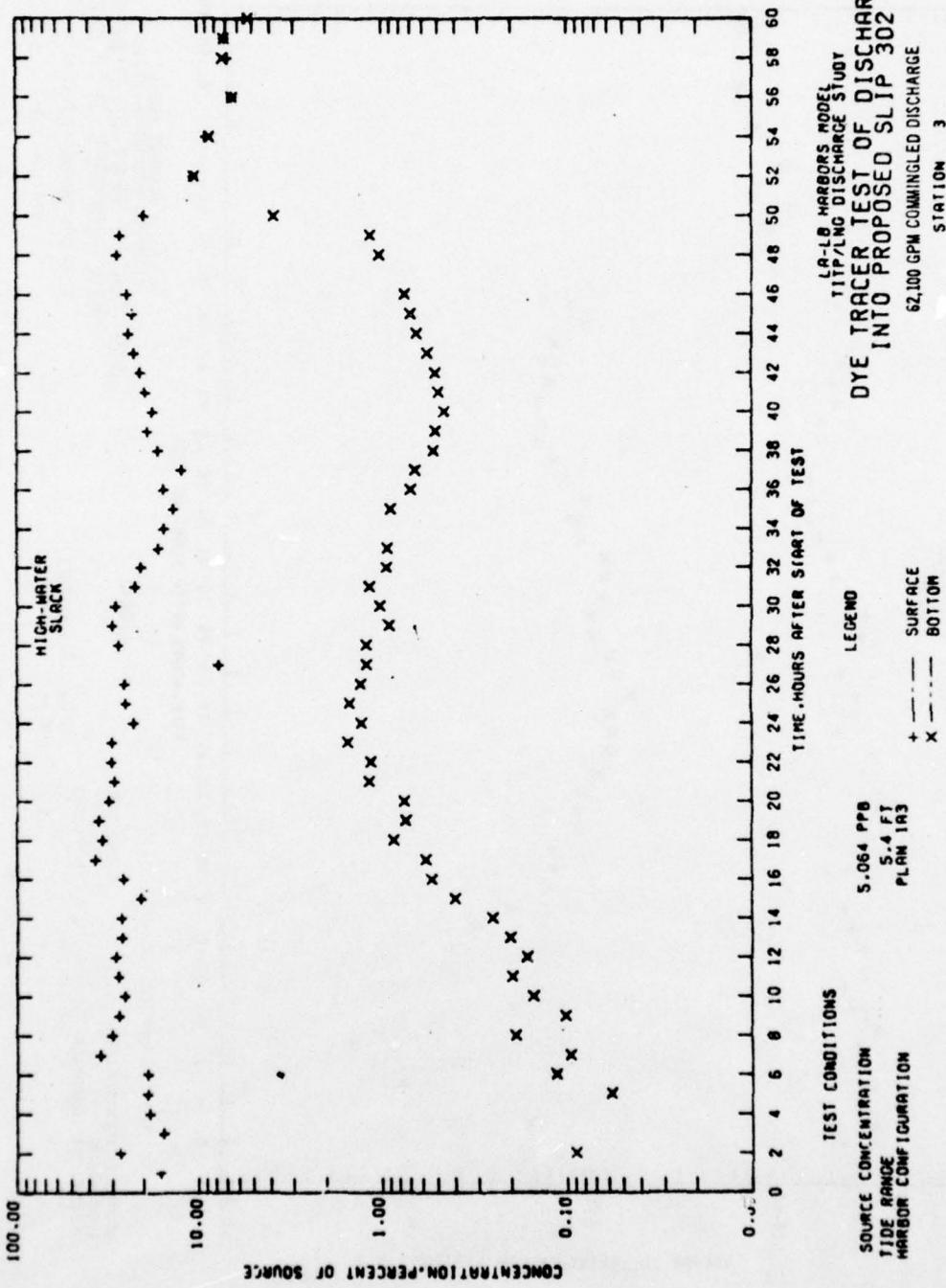
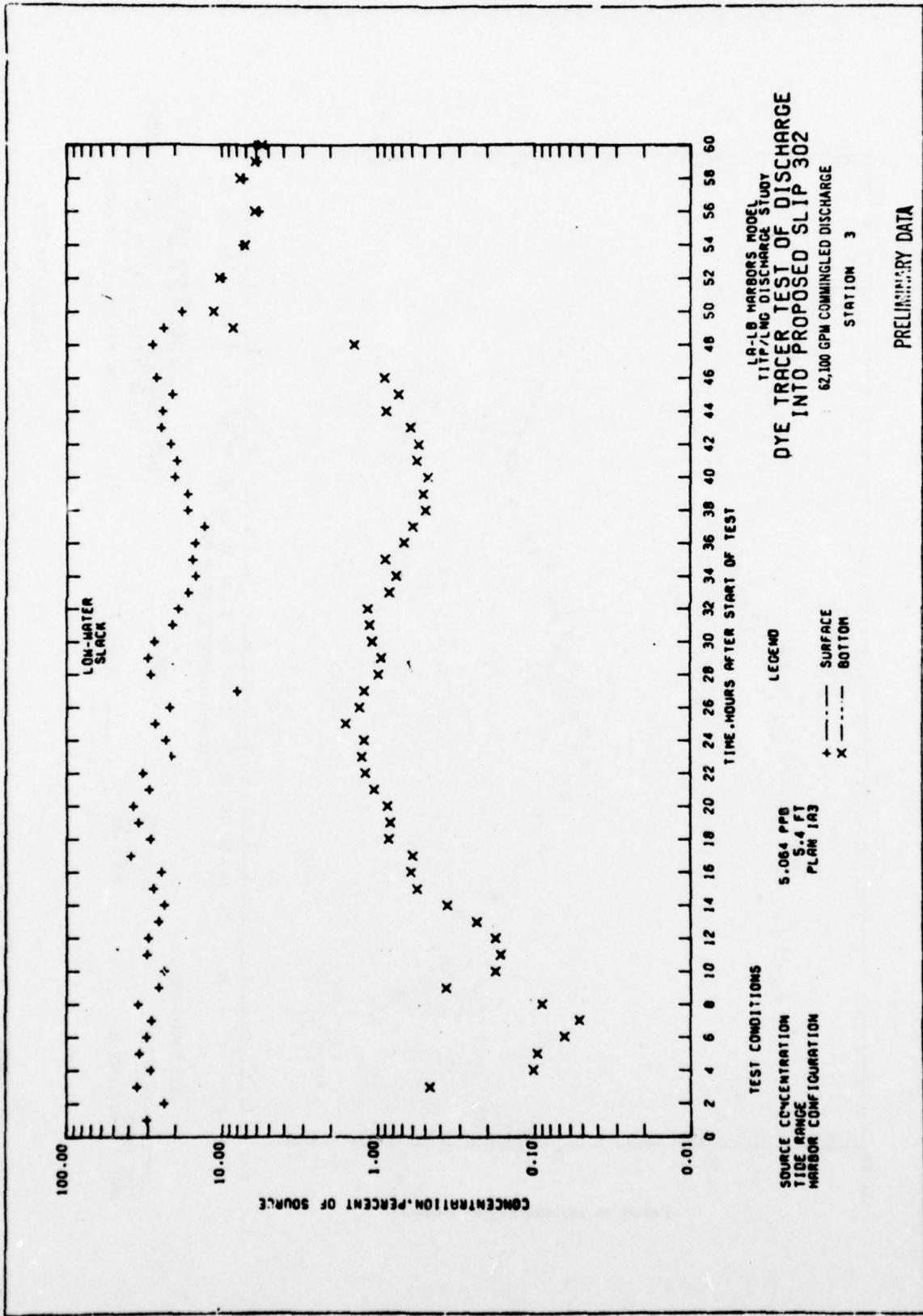


PLATE S113



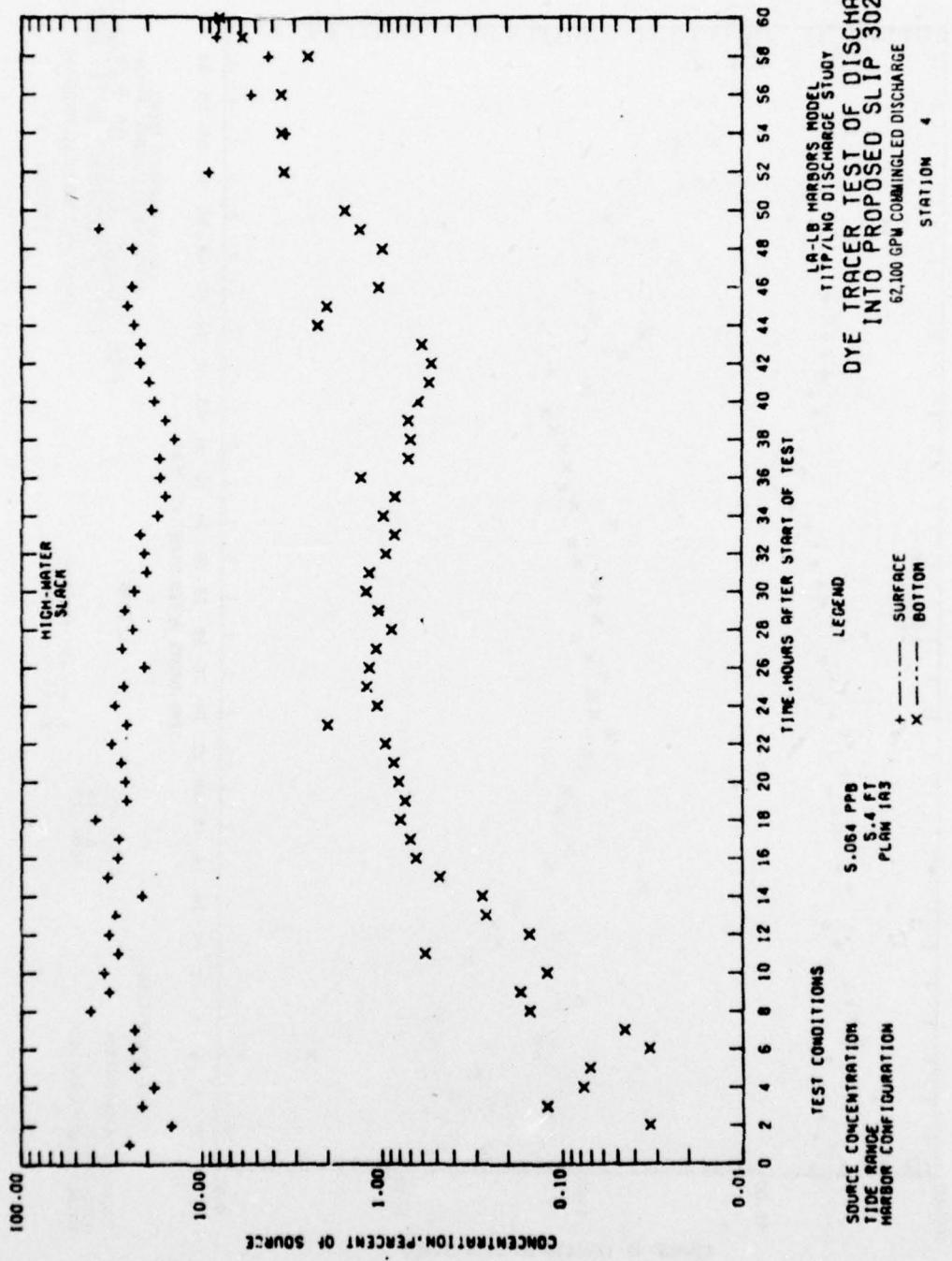
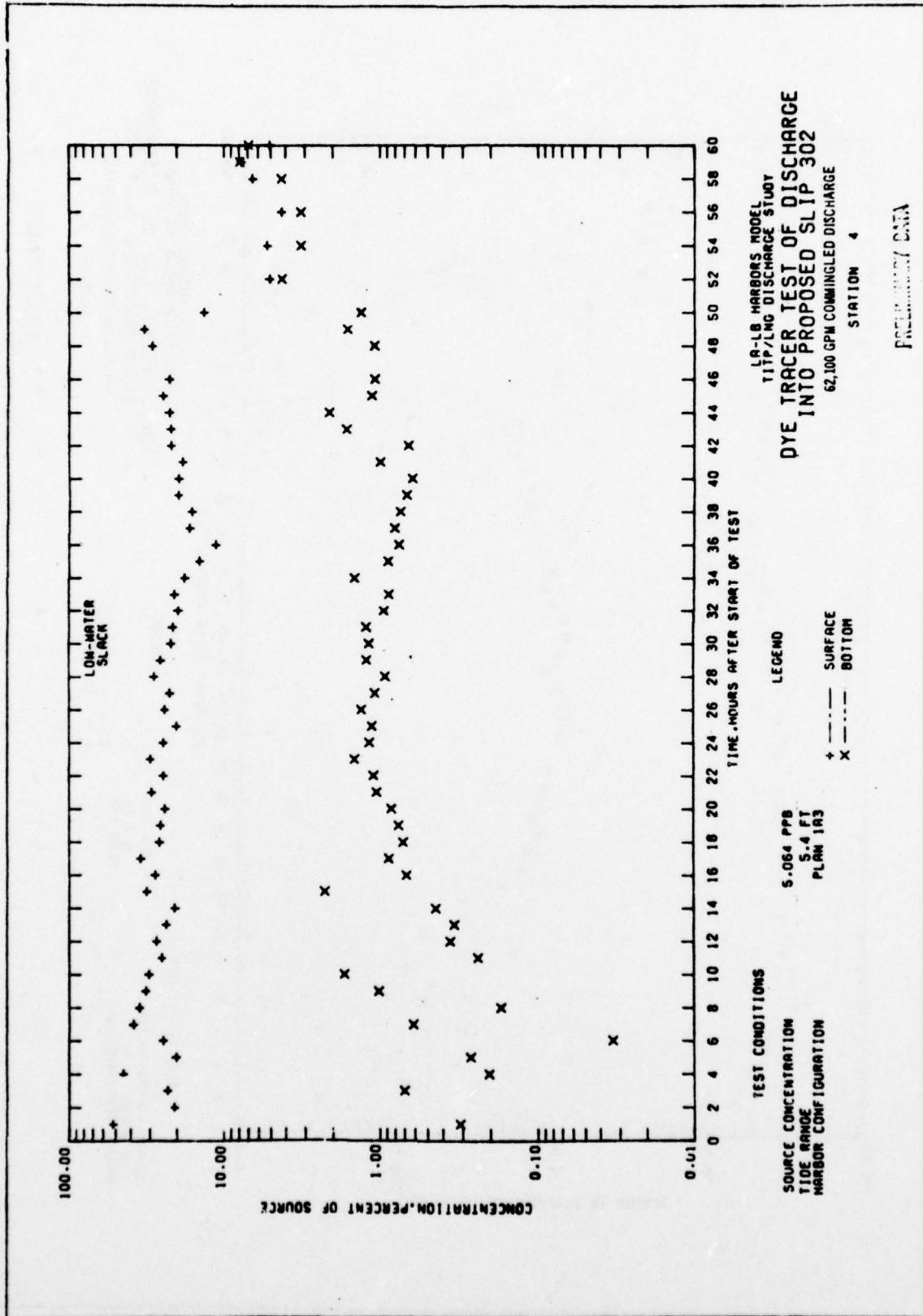


PLATE 5115



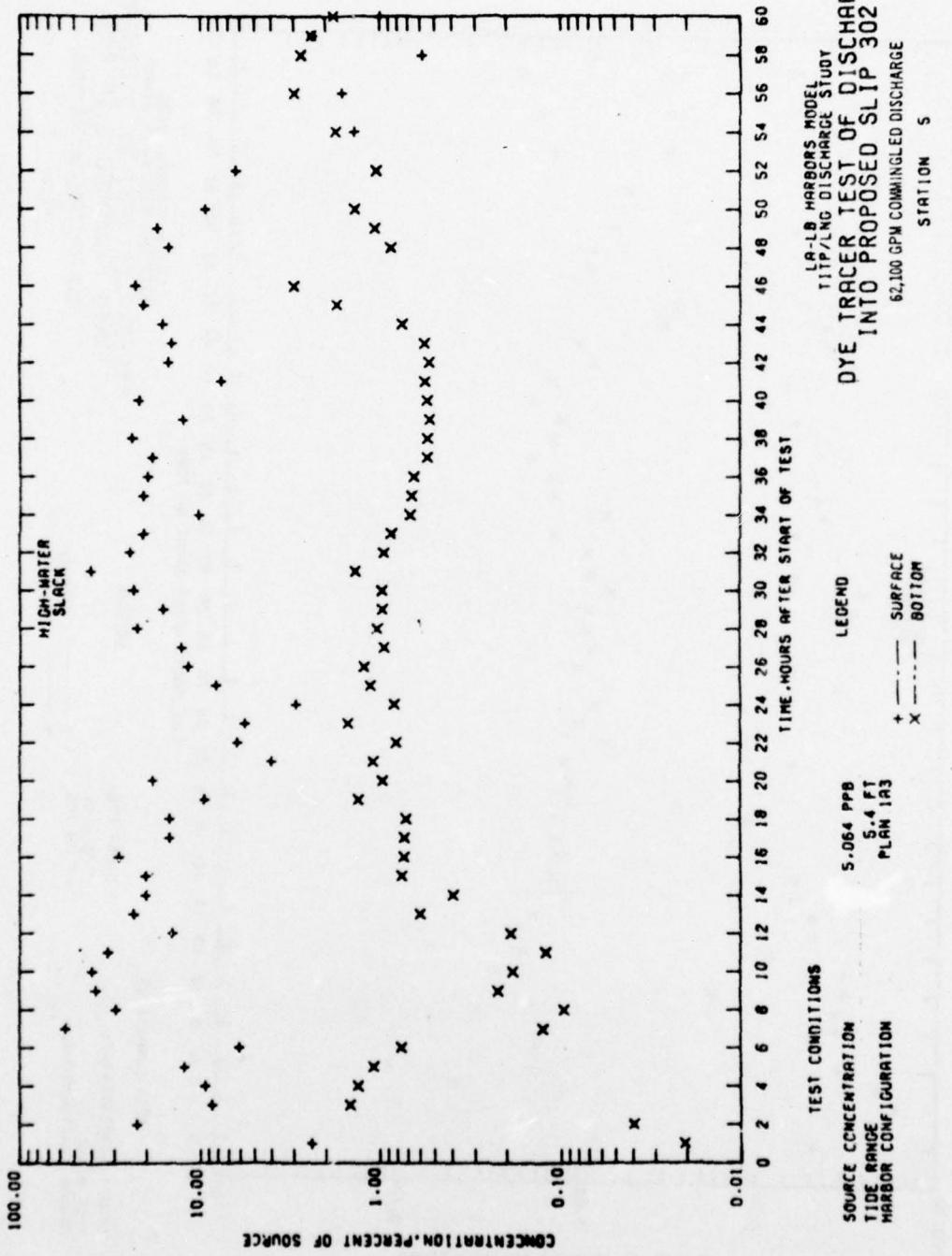
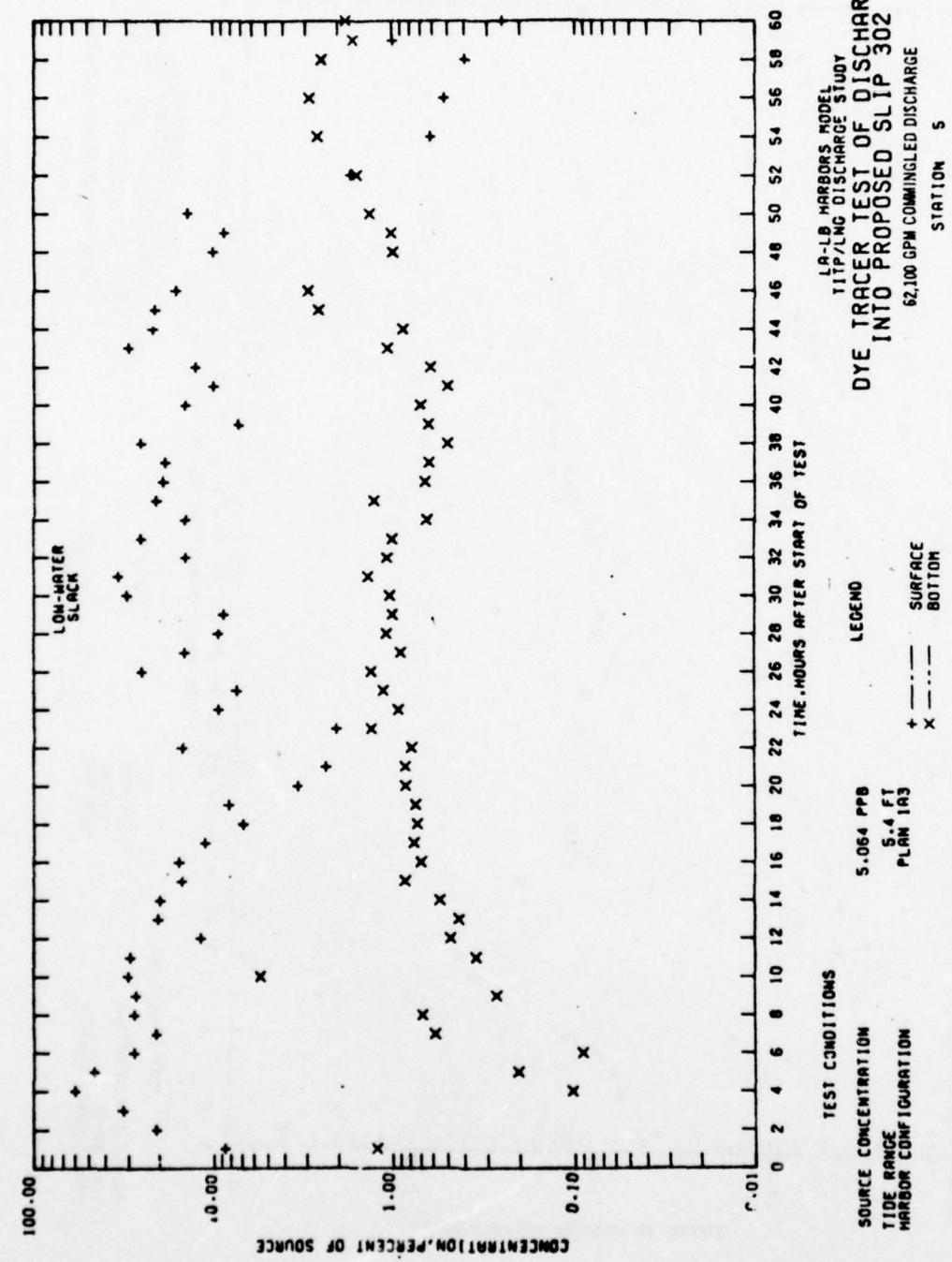
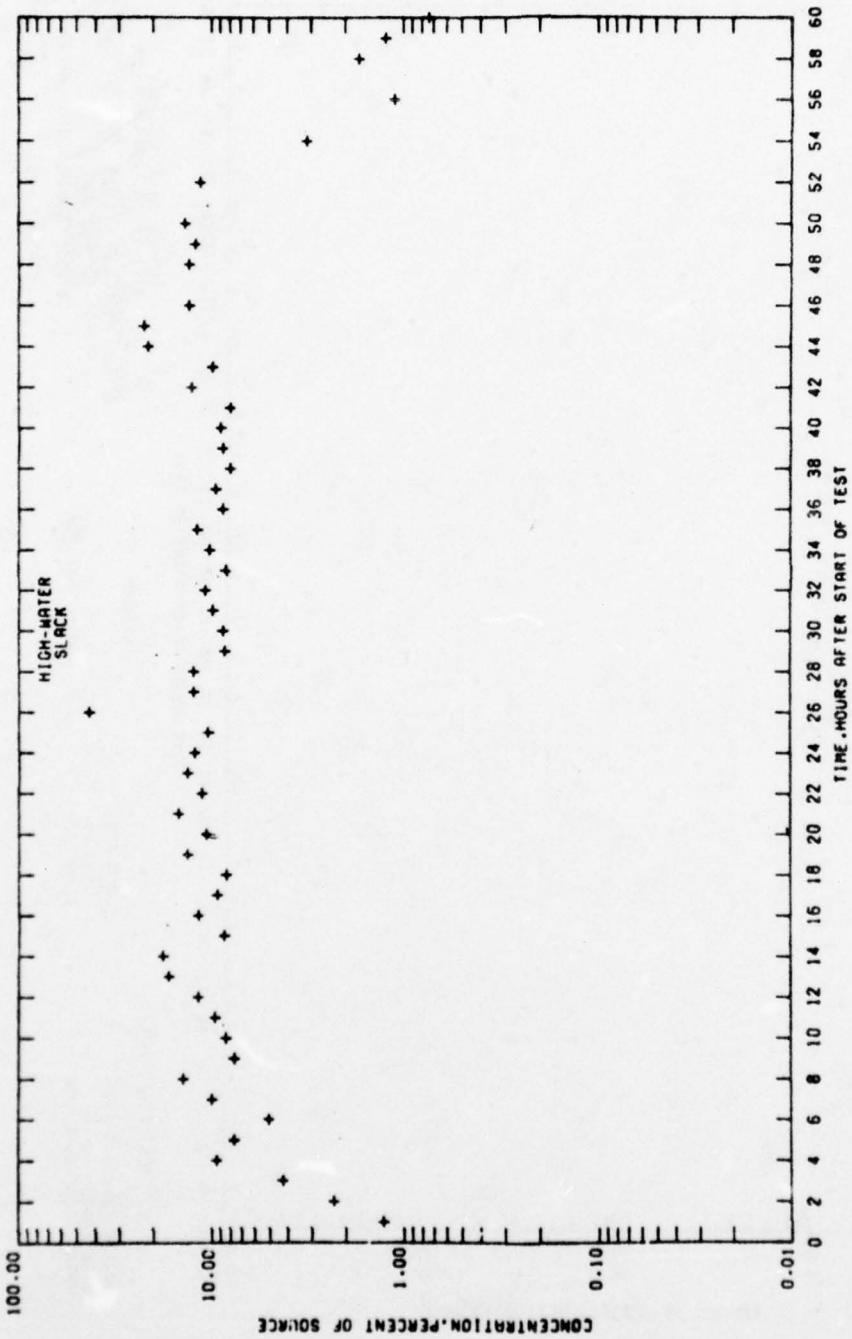
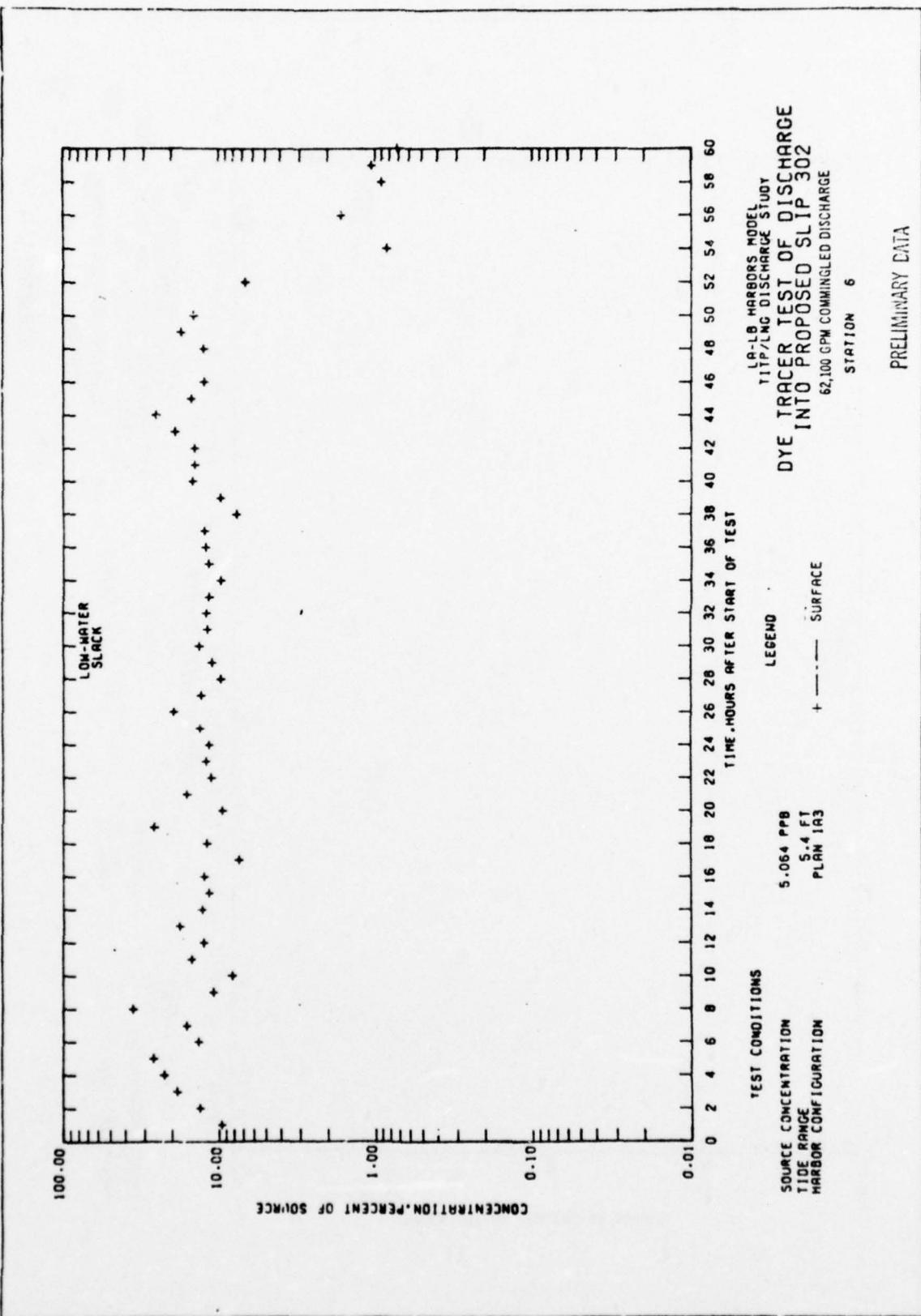


PLATE SLI







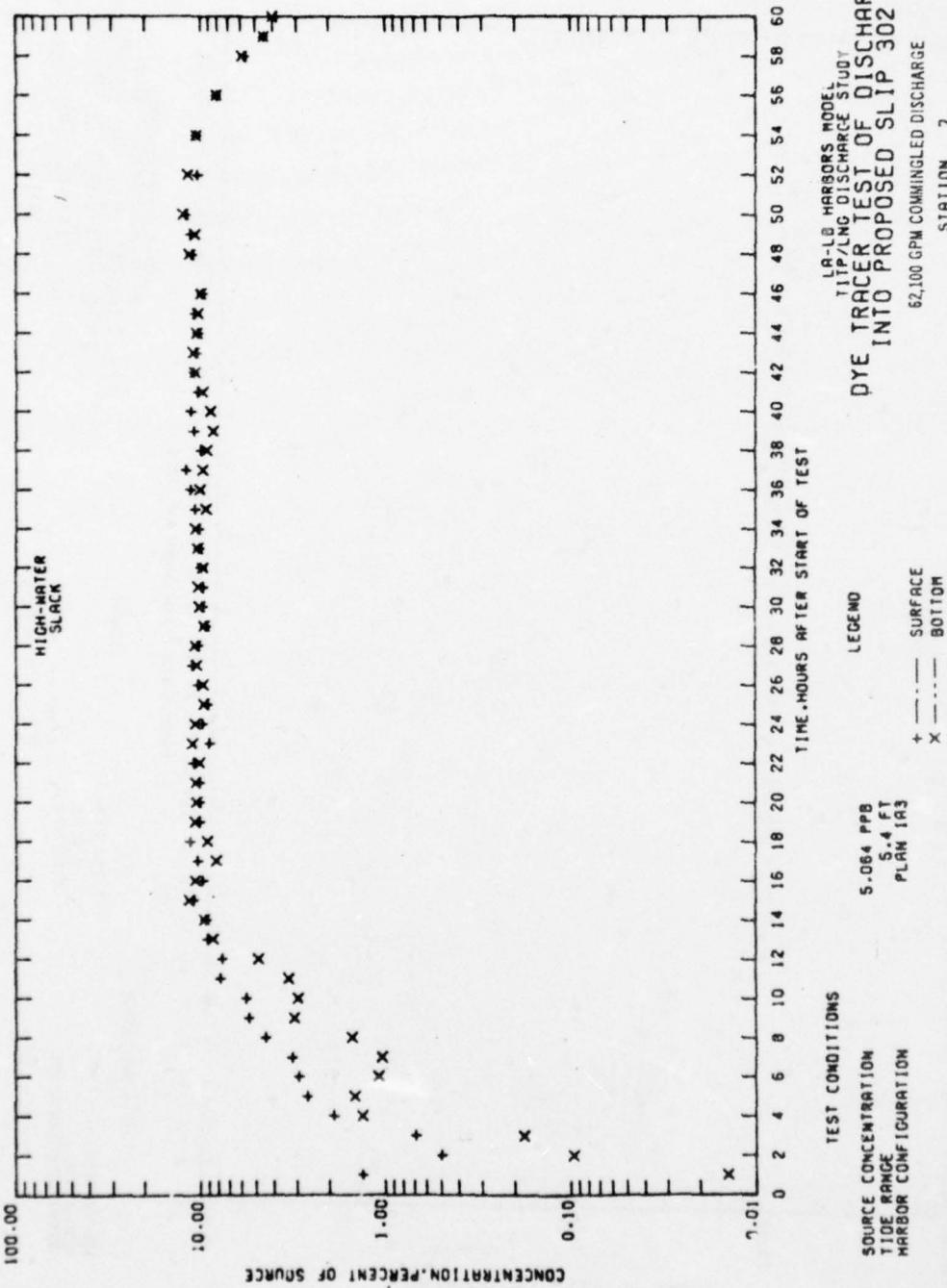
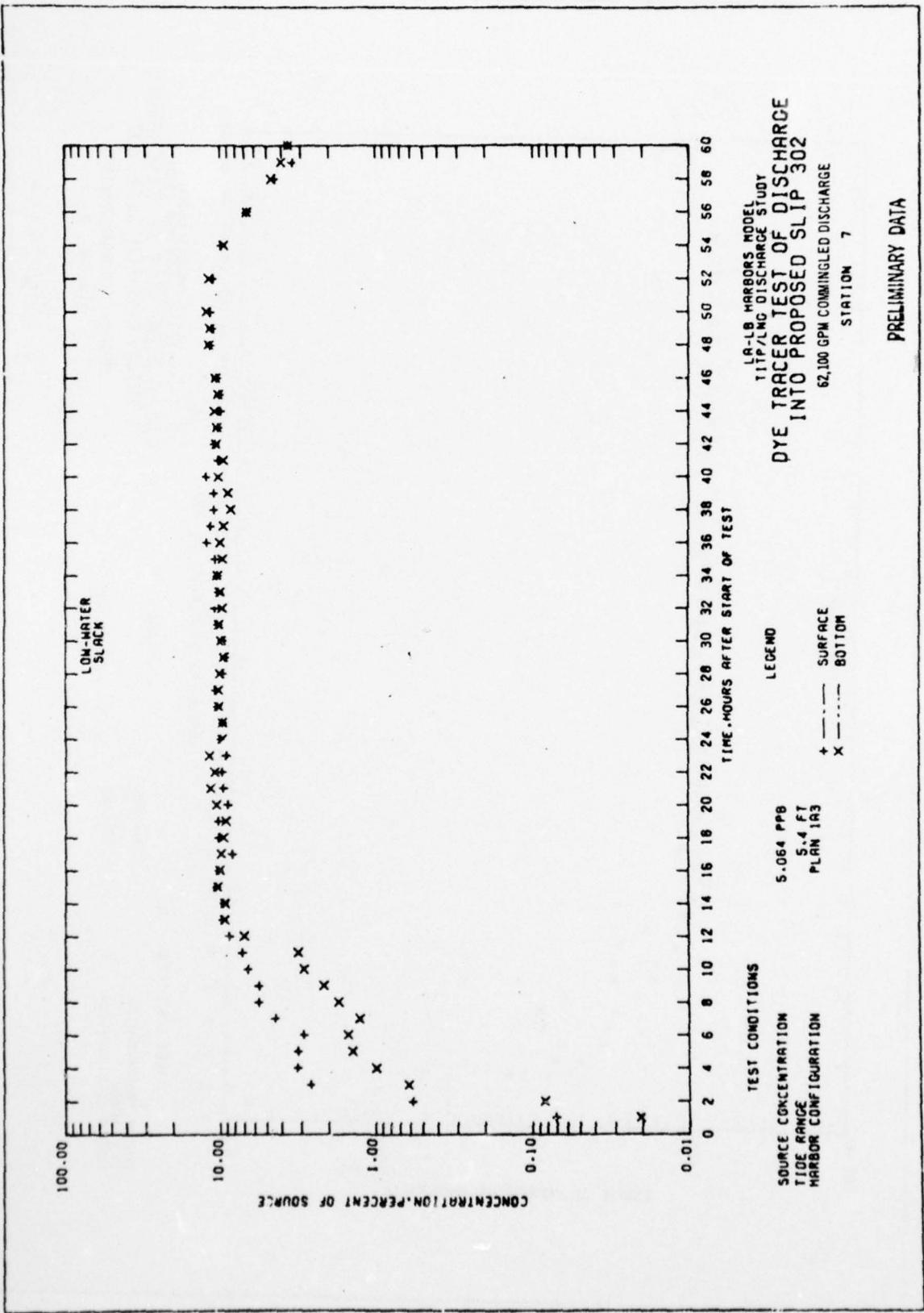
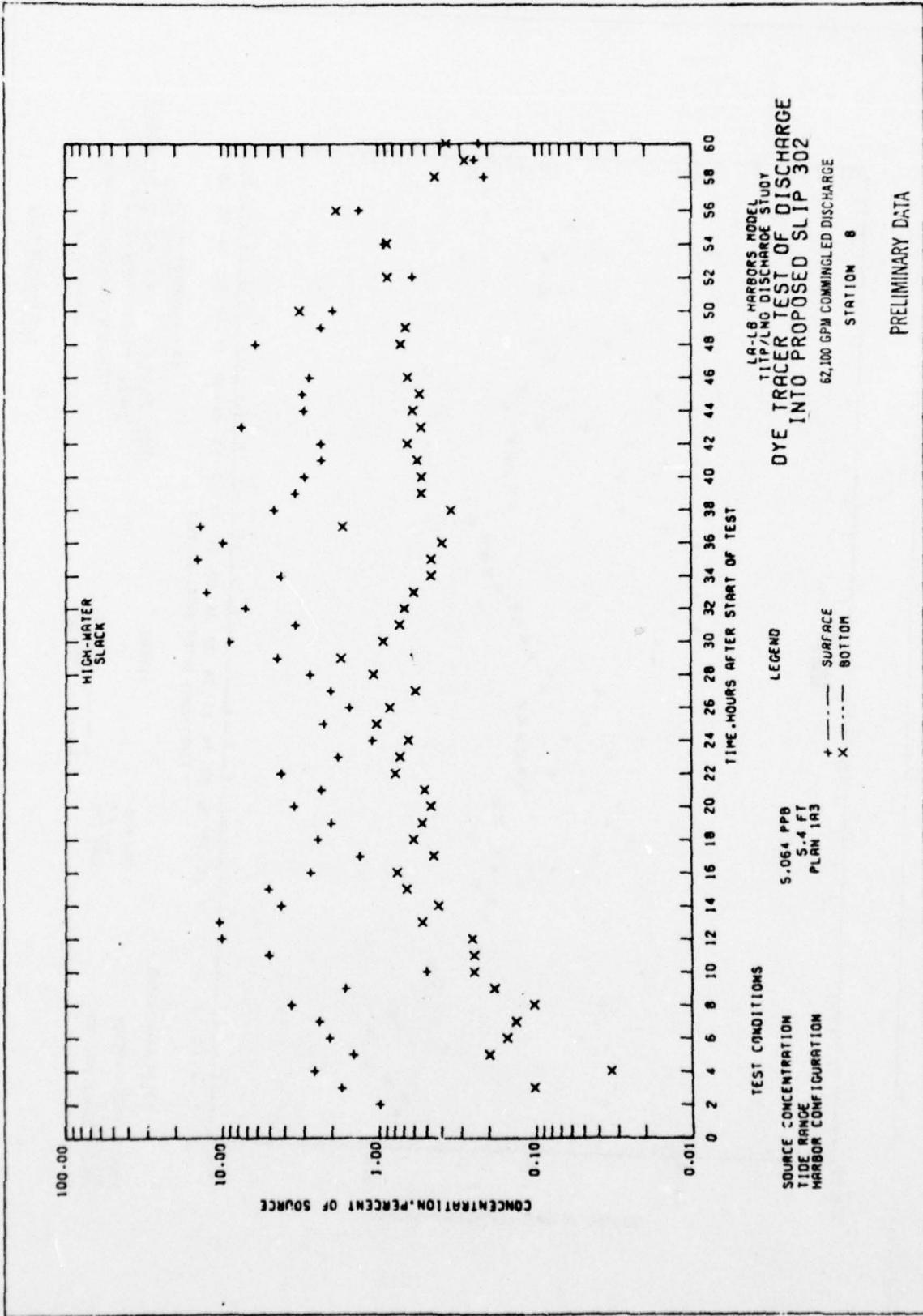
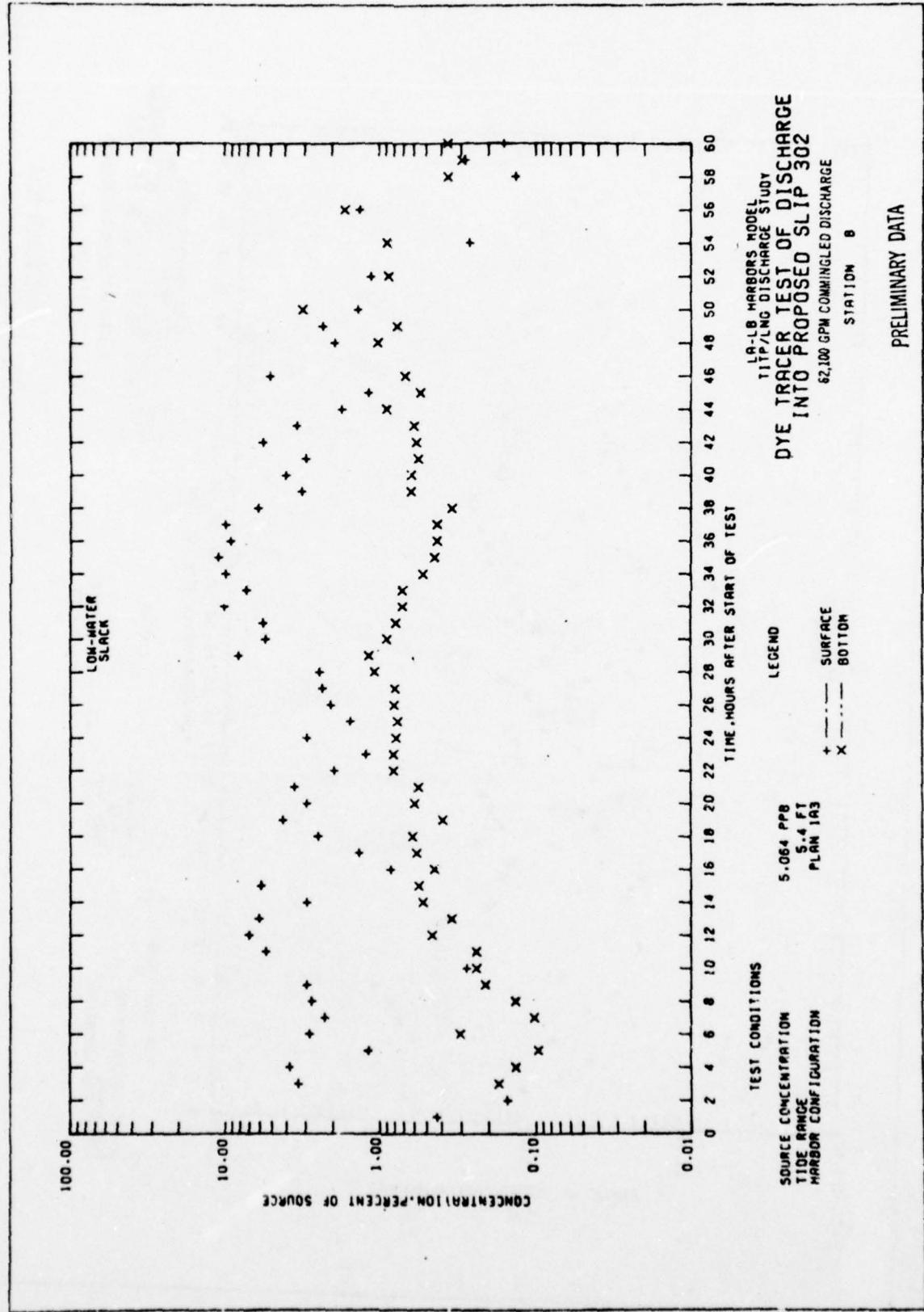
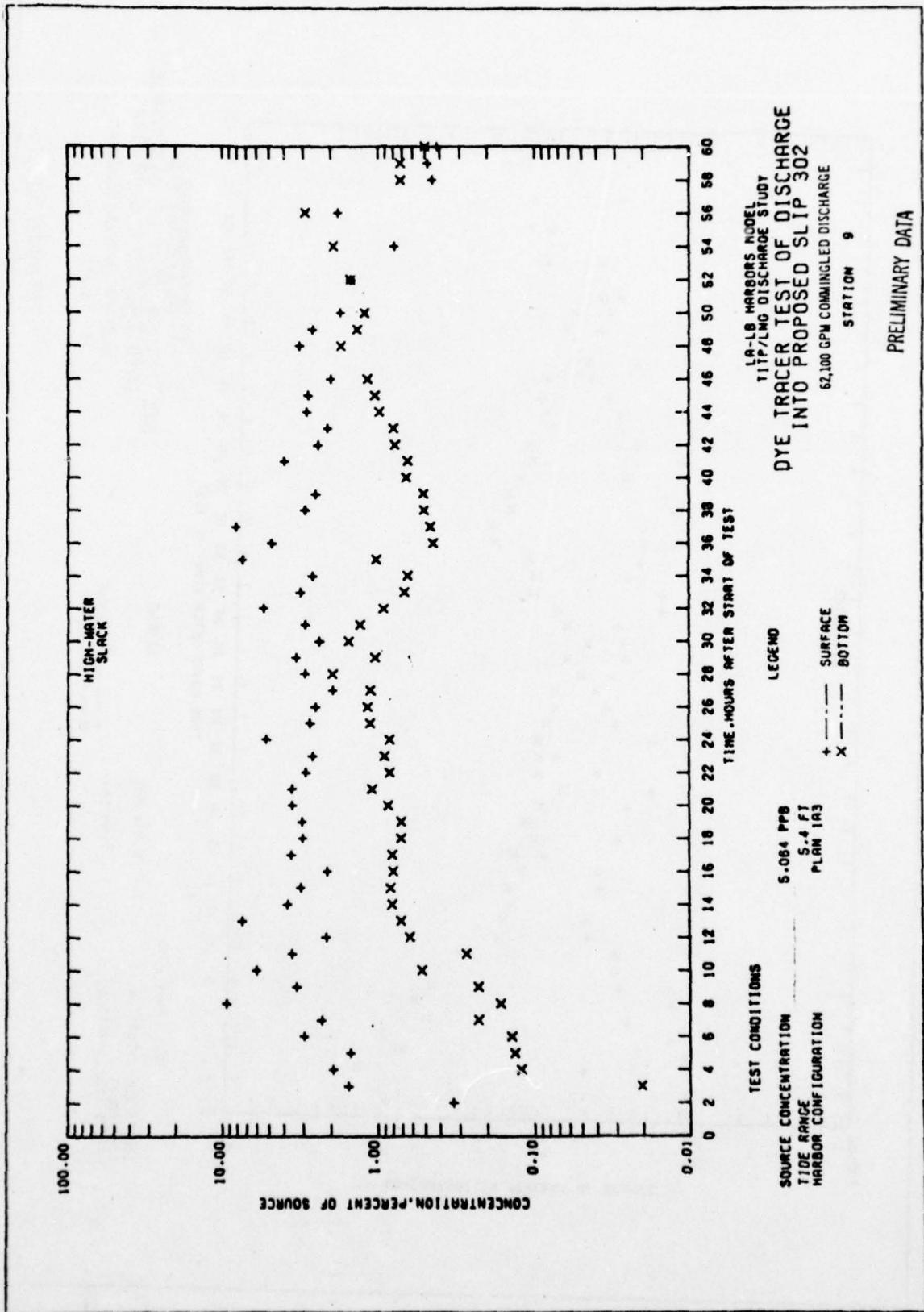


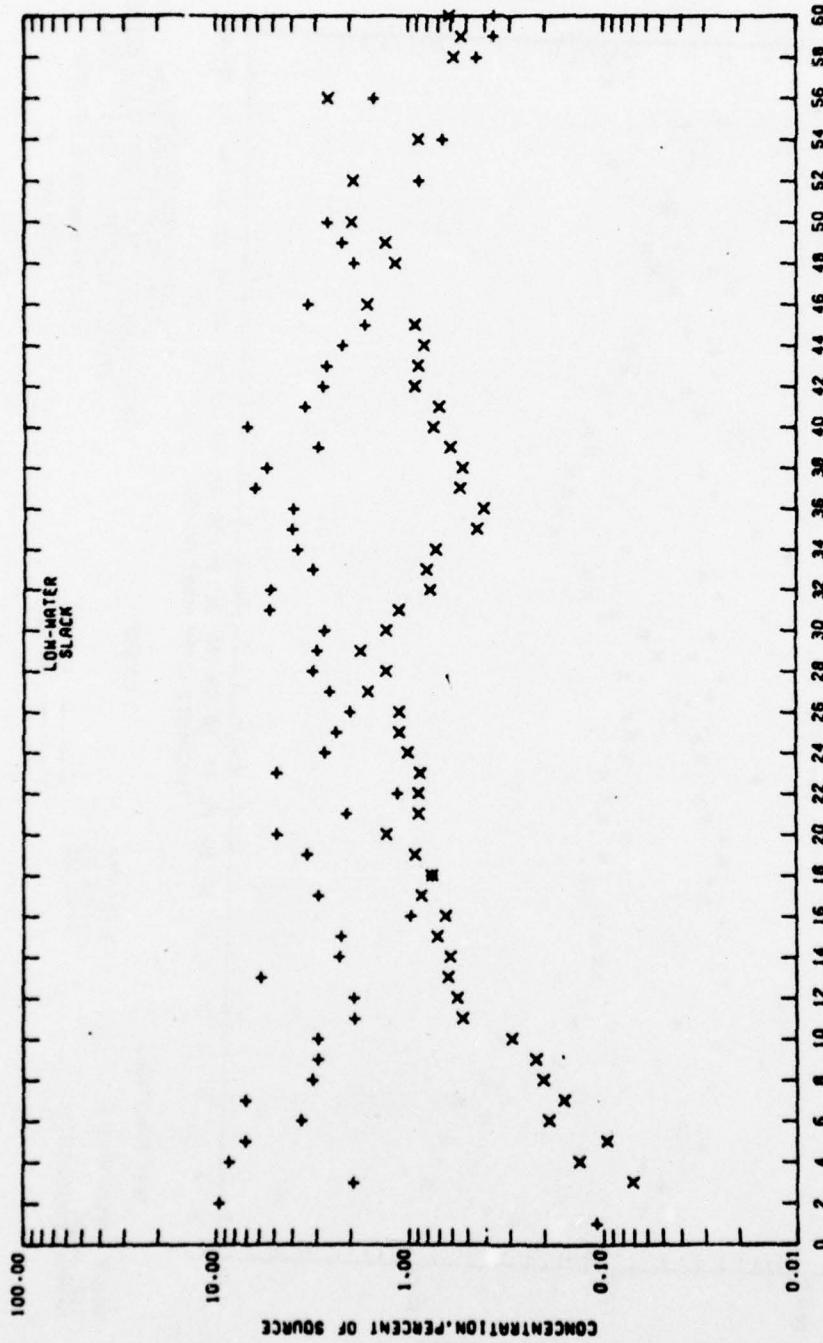
PLATE NO. 2











LA-LB HARBOURS MODEL
TIP/LNG DISCHARGE STUDY
DYE TRACER TEST OF DISCHARGE
INTO PROPOSED SLIP 302
62,100 GPM COMMINGLED DISCHARGE
STATION 9

TEST CONDITIONS

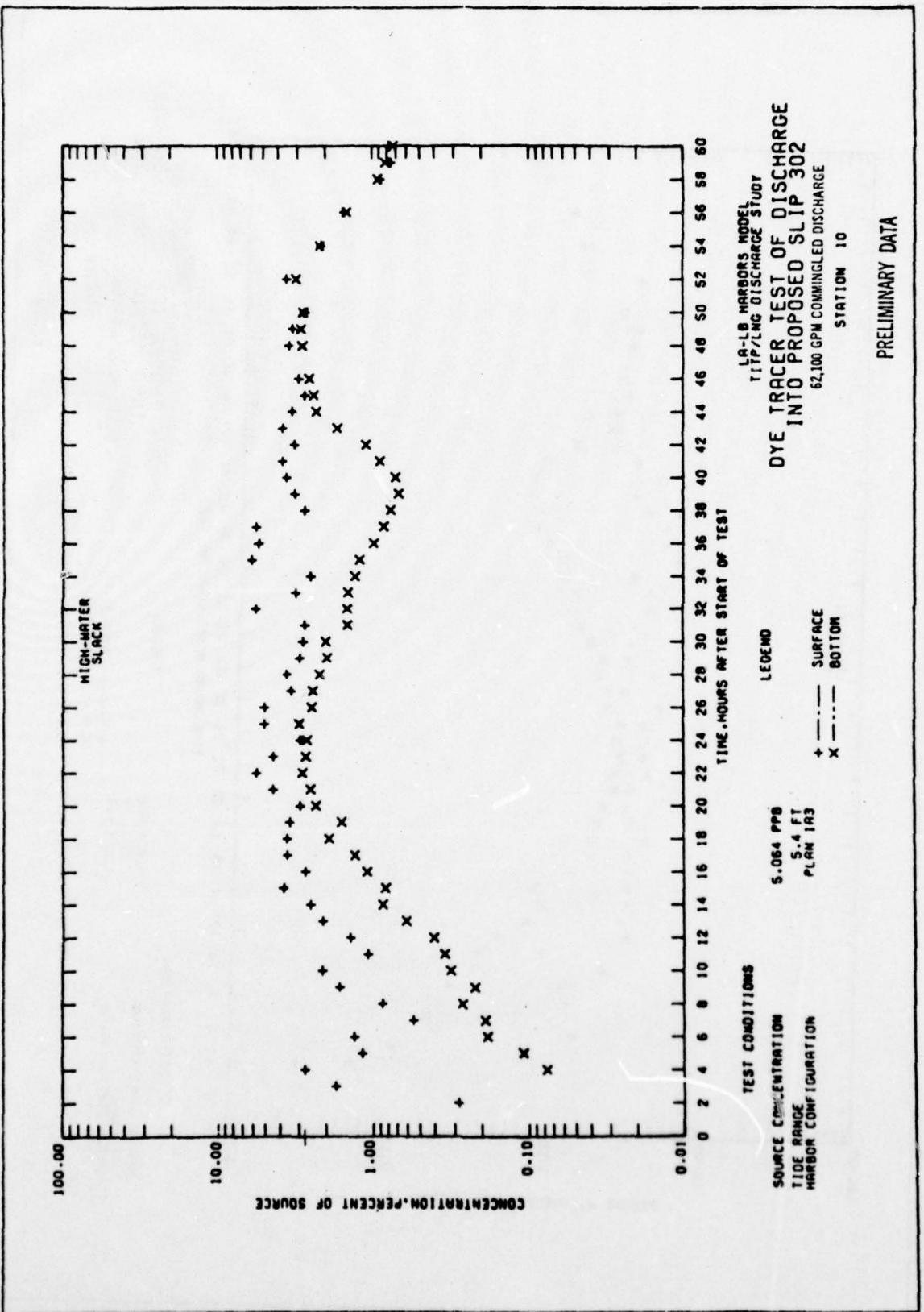
SOURCE CONCENTRATION 5,064 PPG
TIDE RANGE 5.4 FT
HARBOR CONFIGURATION PLAIN 1A3

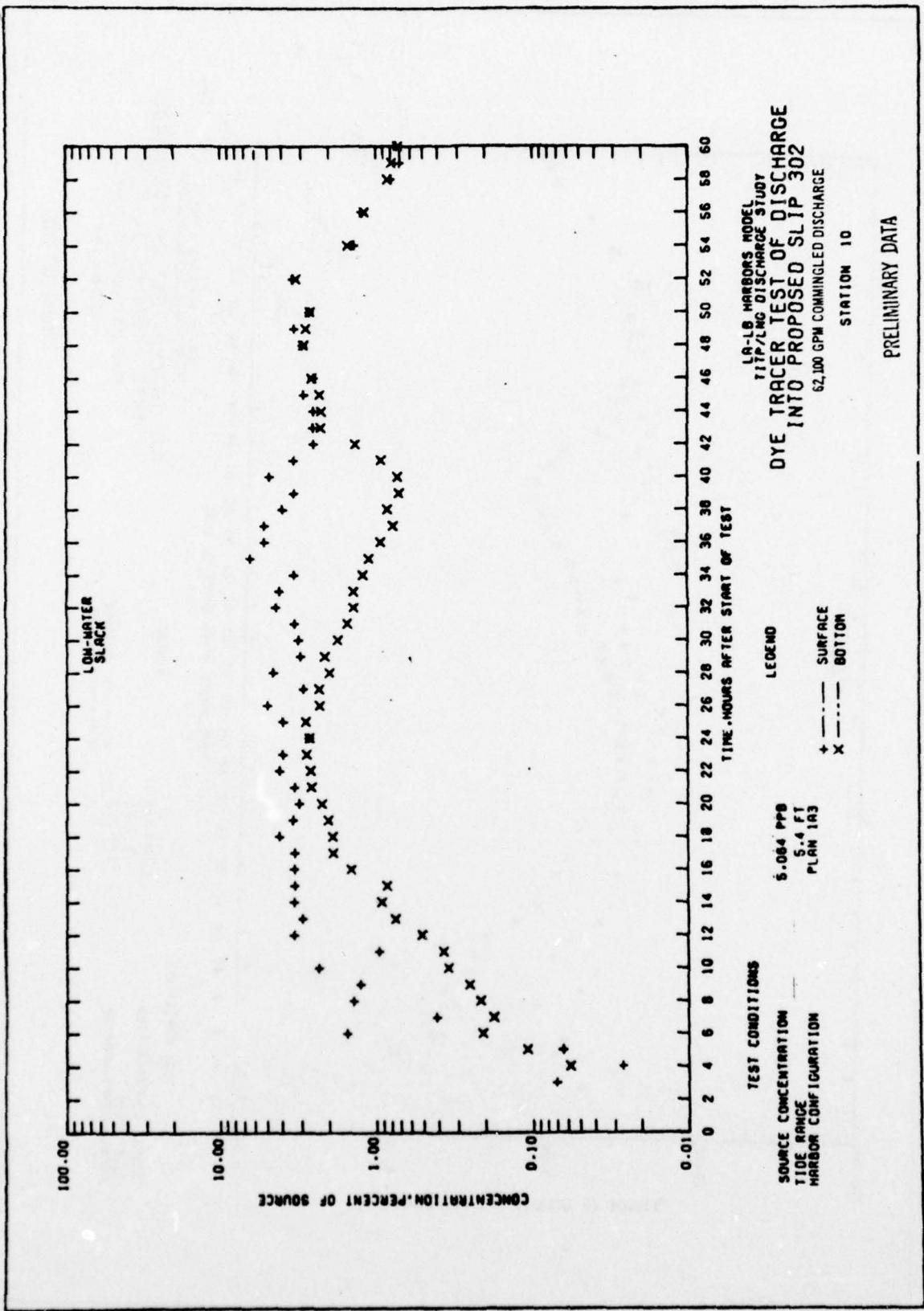
LEGEND

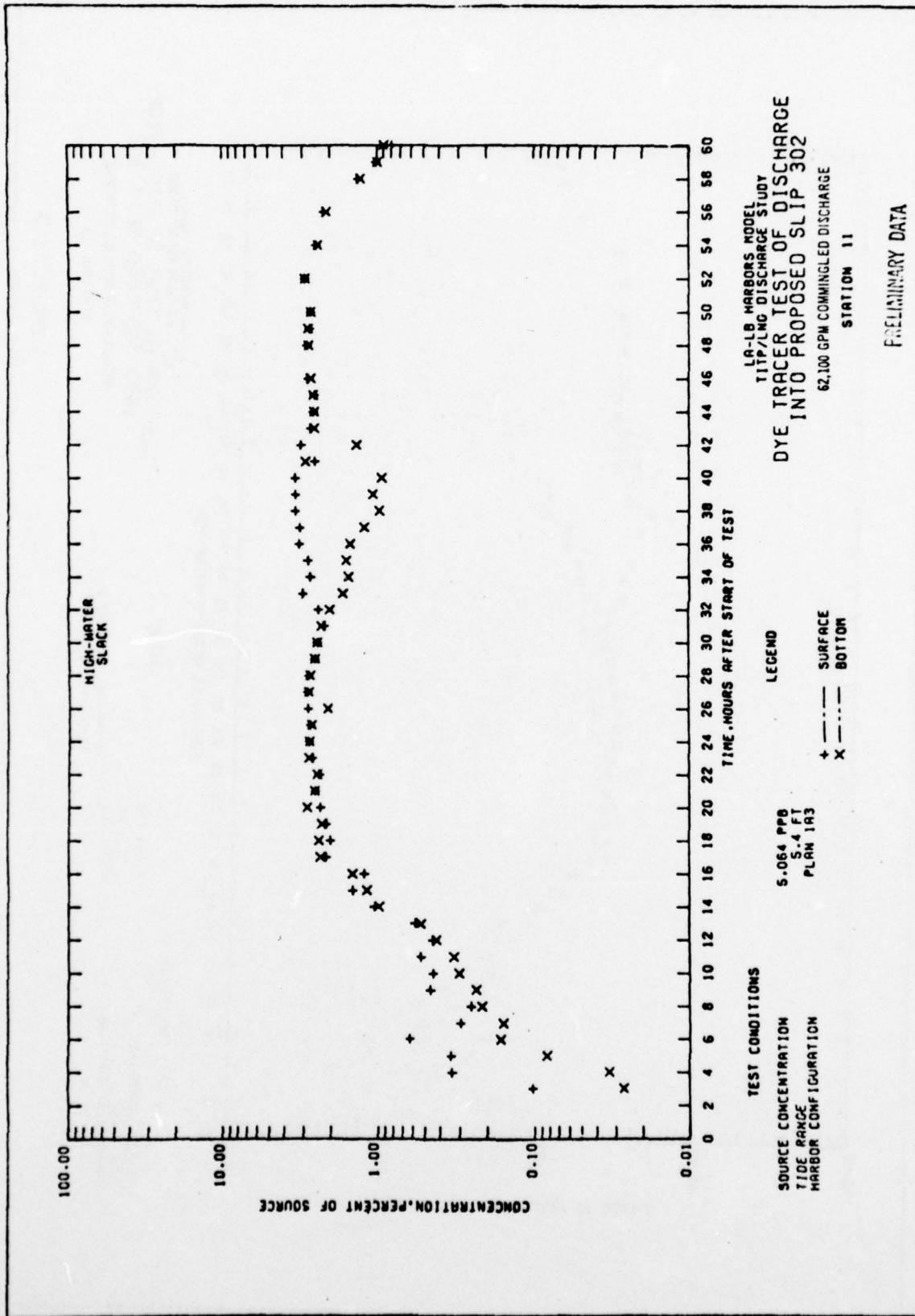
+ —— SURFACE
x —— BOTTOM

PRELIMINARY DATA

PLATE SLAB







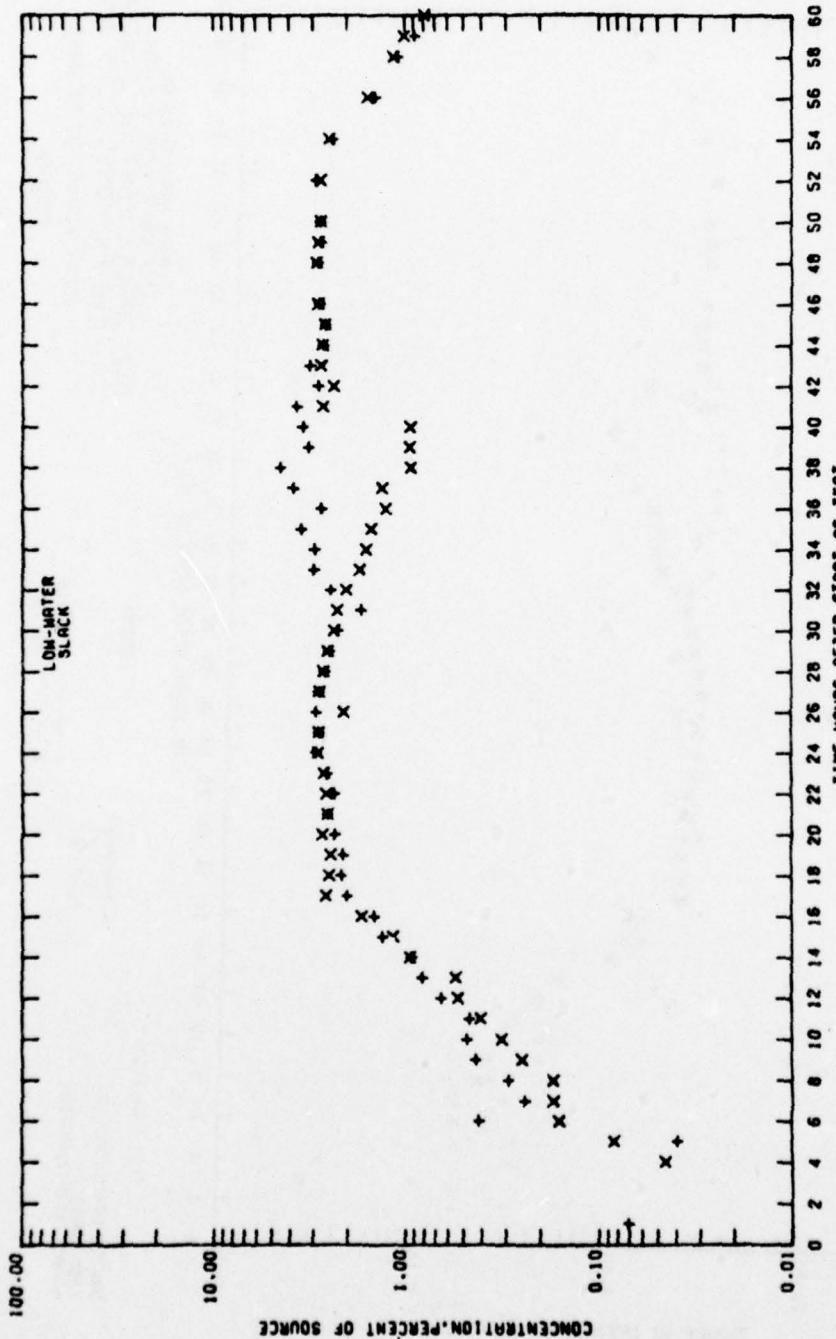
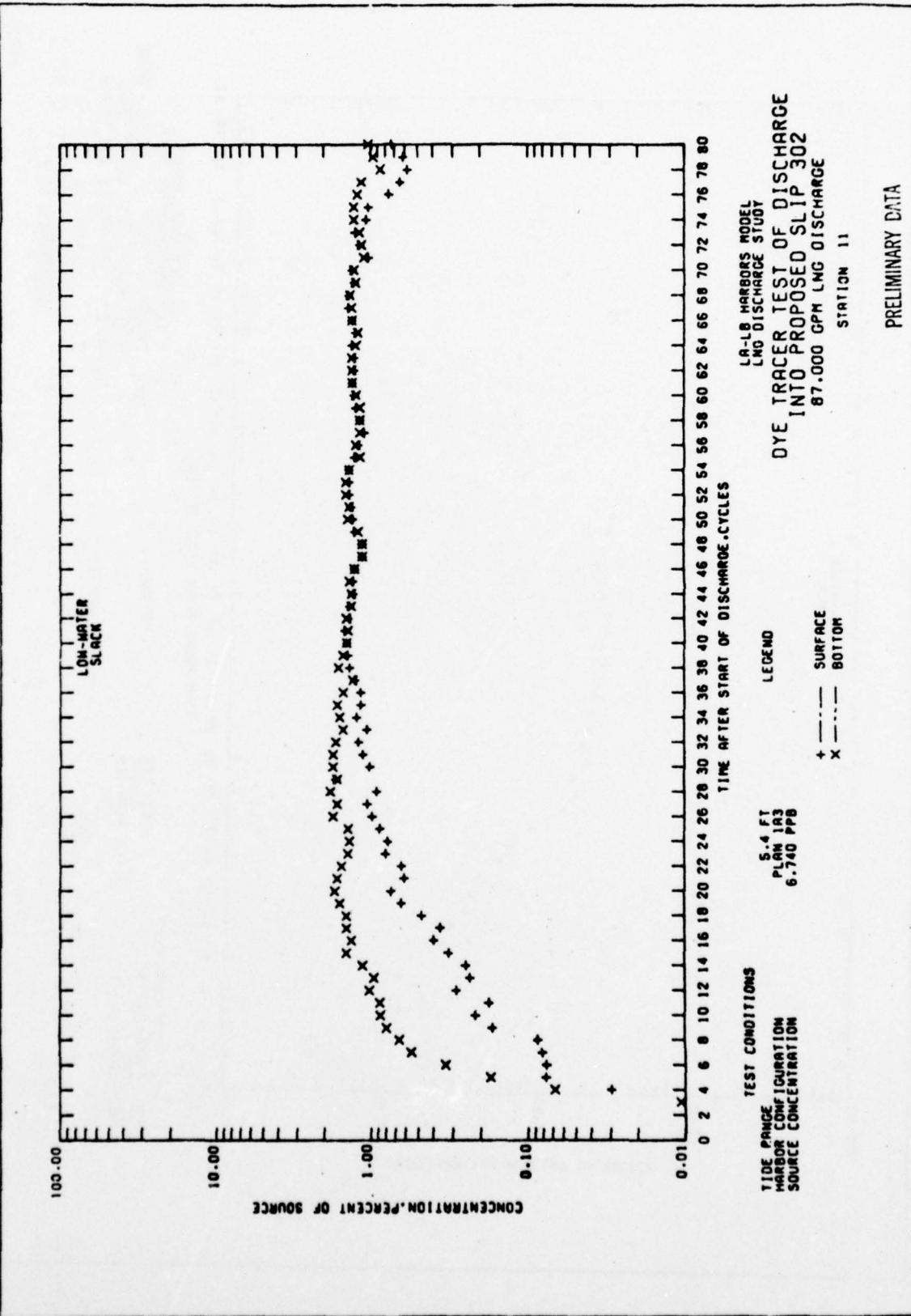


PLATE 5E52

PRELIMINARY DATA



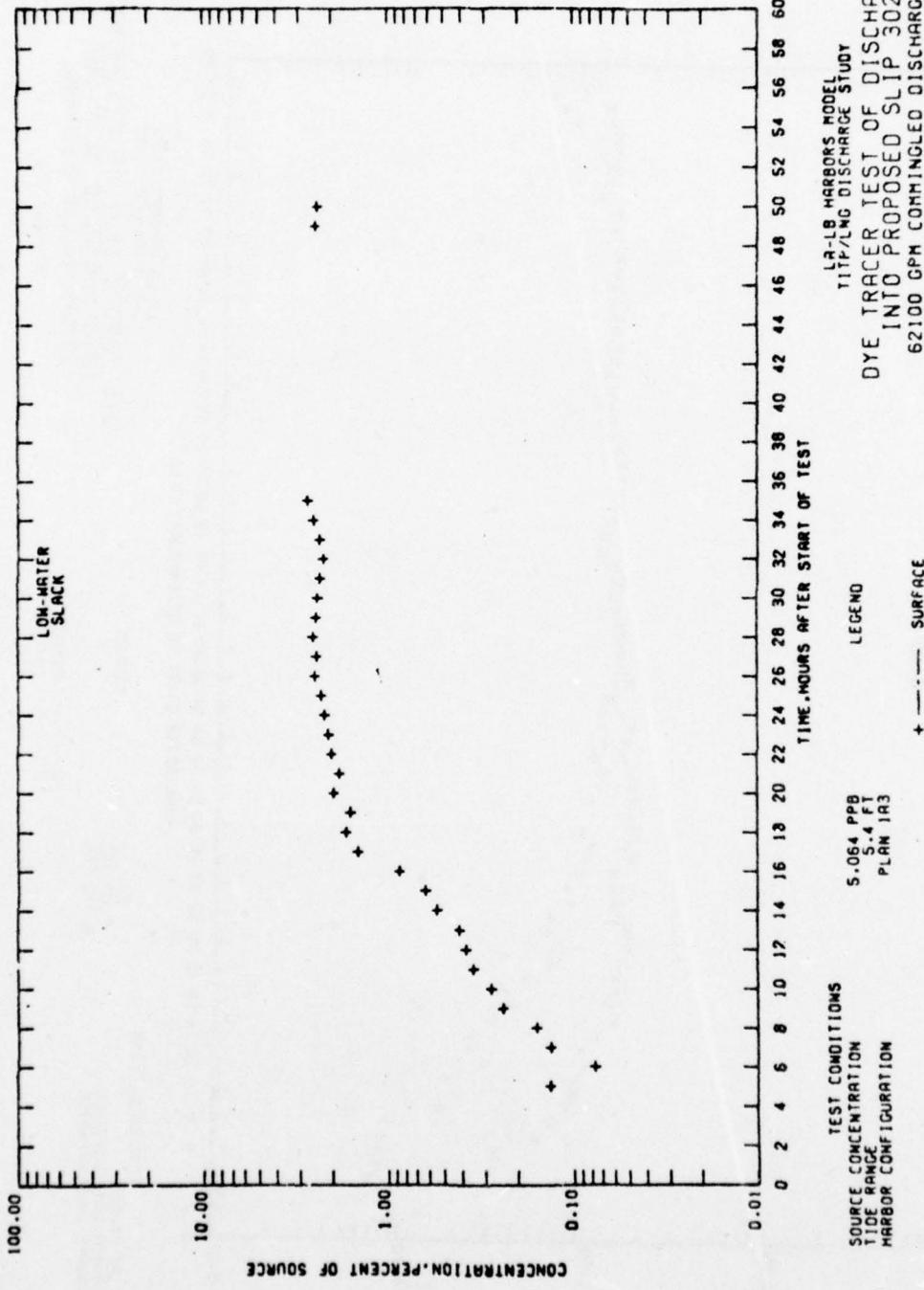
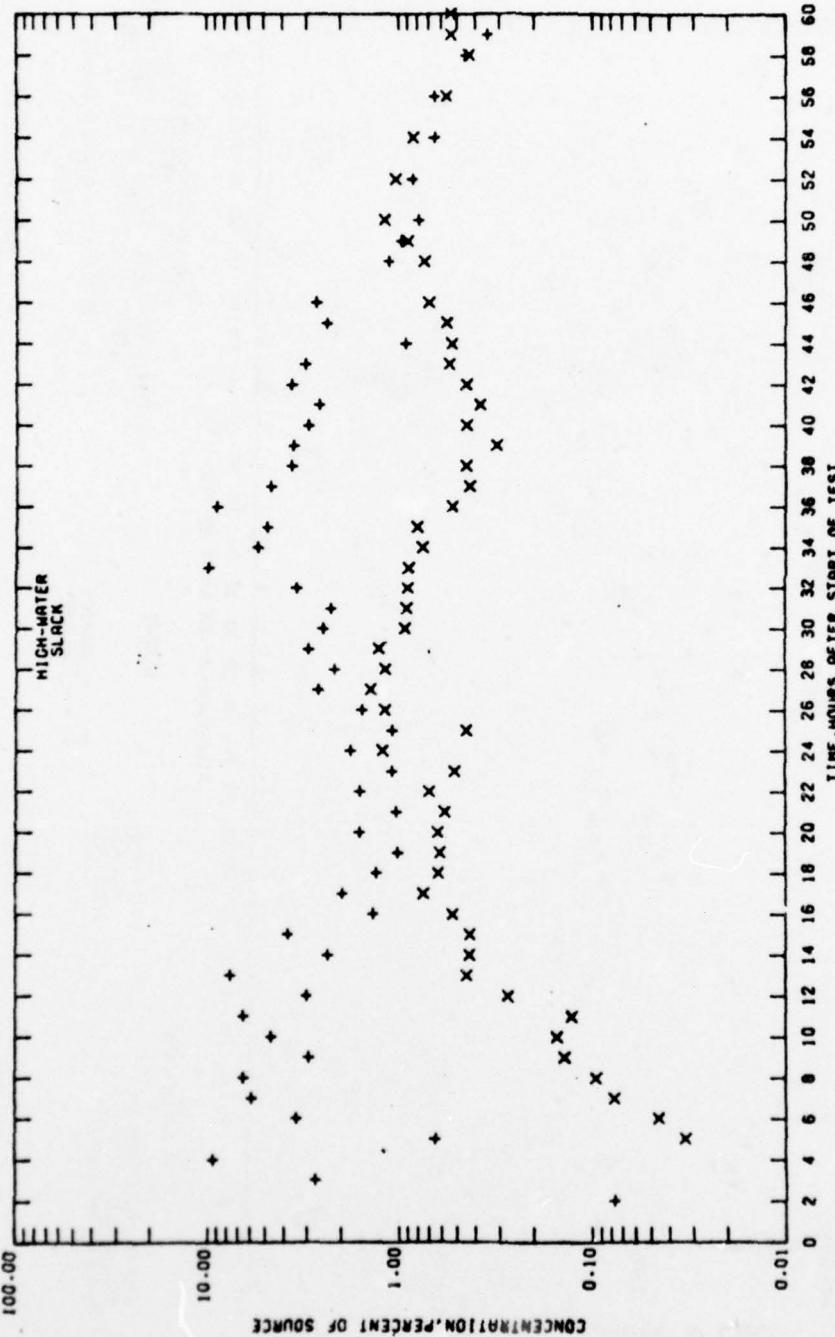


PLATE 55:

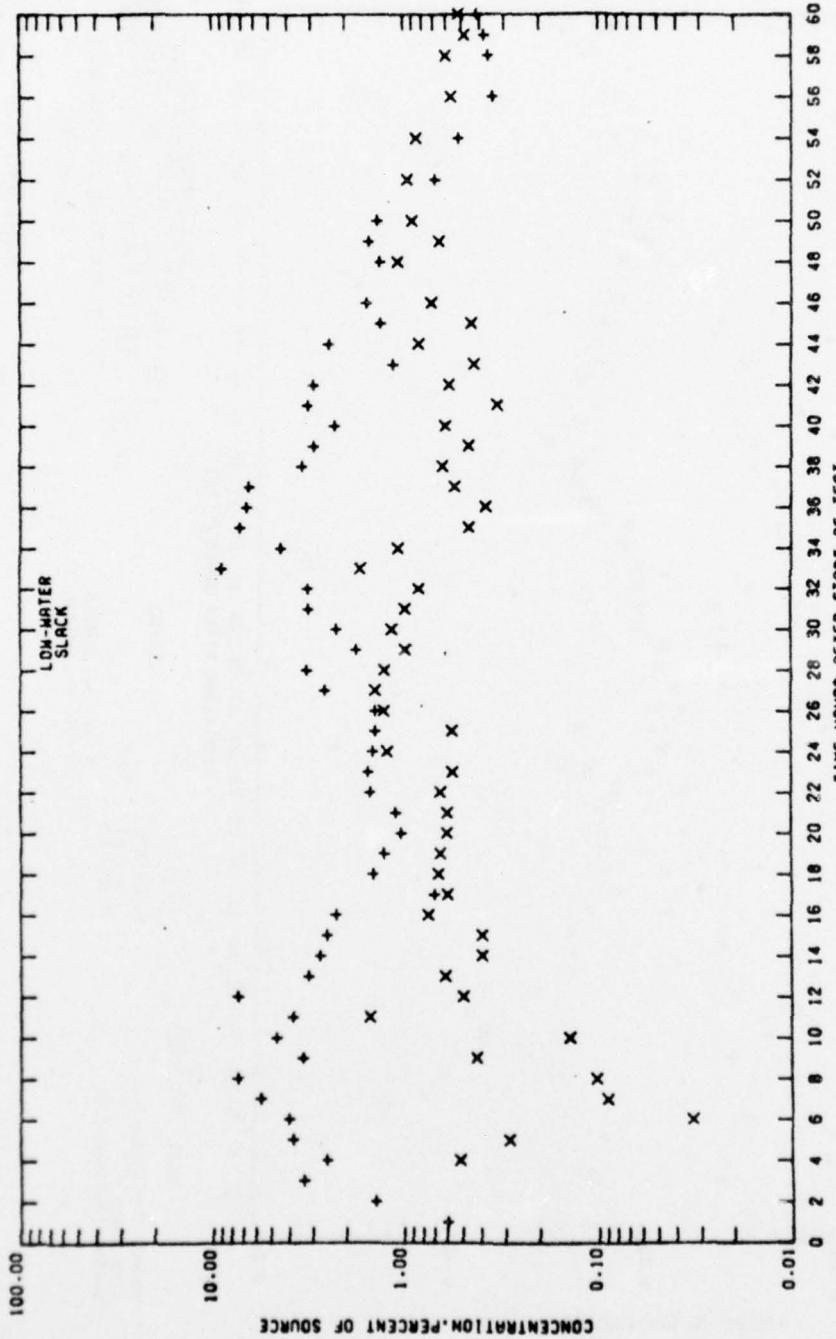


LA-18 HARBOURS MODEL
TIPPING DISCHARGE STUDY
DYE TRACER TEST OF DISCHARGE
INTO PROPOSED SLIP 302

62,100 GPM COMMINGLED DISCHARGE
STATION 13

PRELIMINARY DATA

PLATE 513

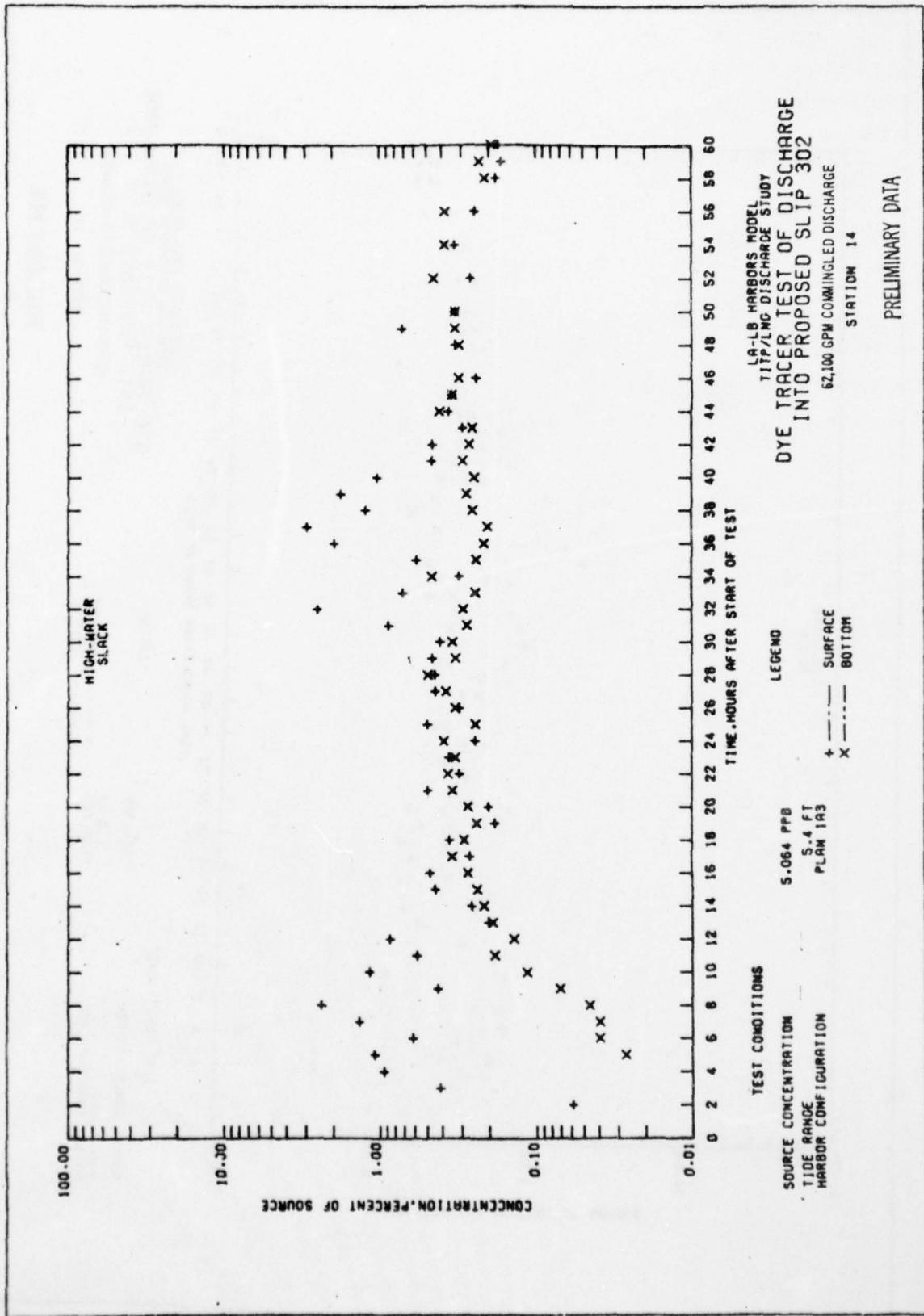


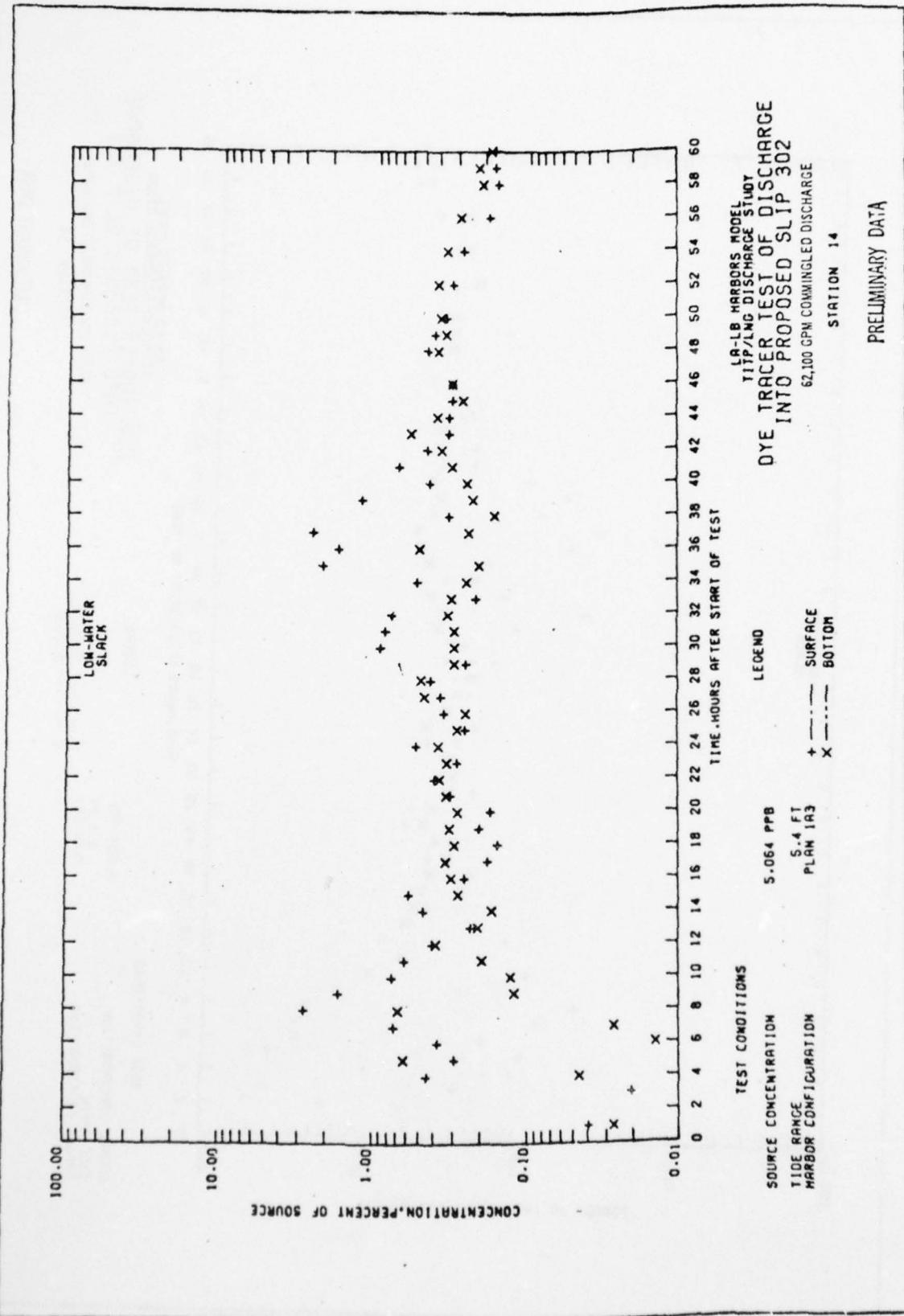
LA-LB HARBOURS MODEL
TITP/LNG DISCHARGE STUDY
DYE TRACER TEST OF DISCHARGE
INTO PROPOSED SLIP 302

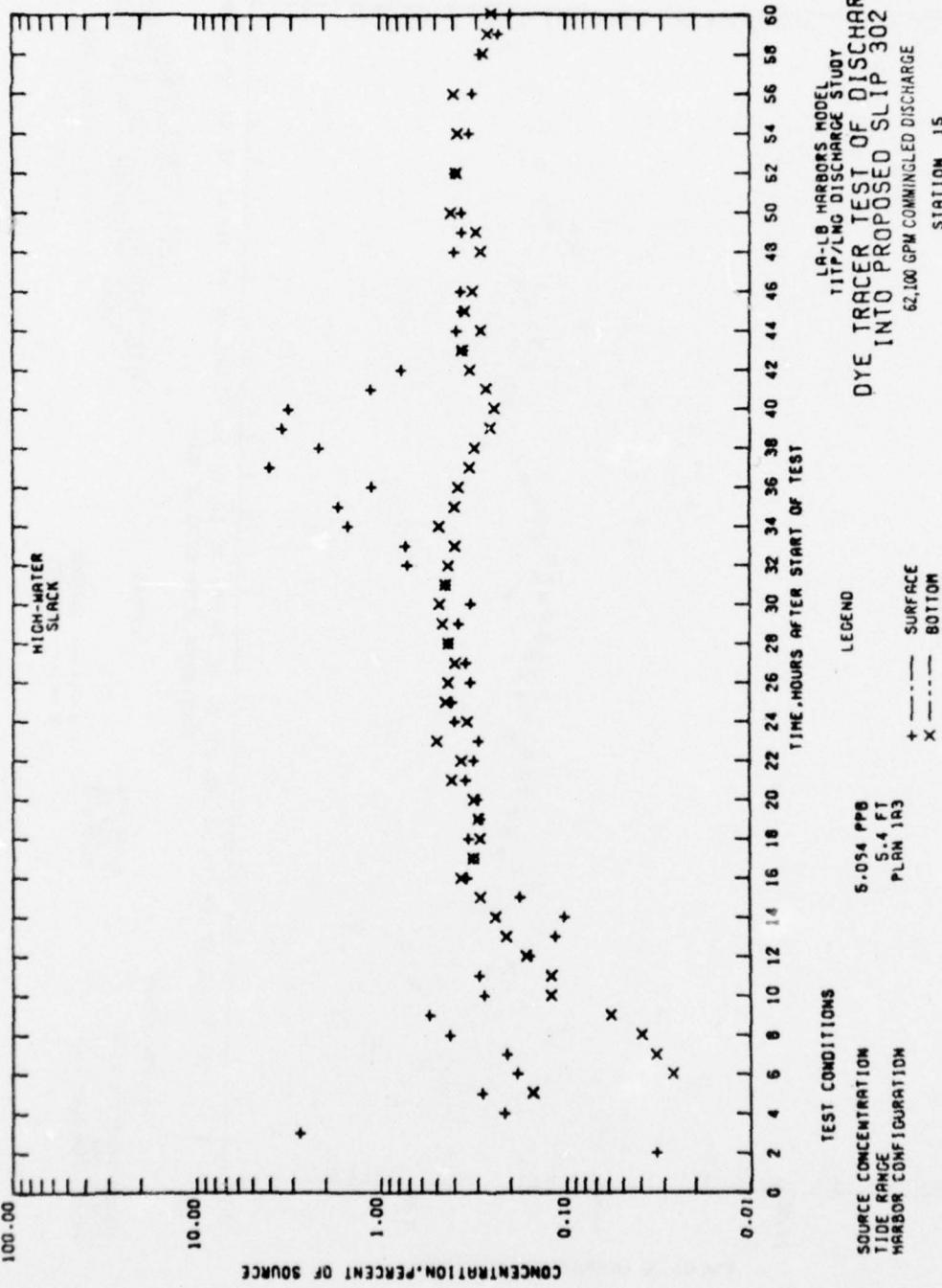
62,100 GPM COMMINGLED DISCHARGE
STATION 13

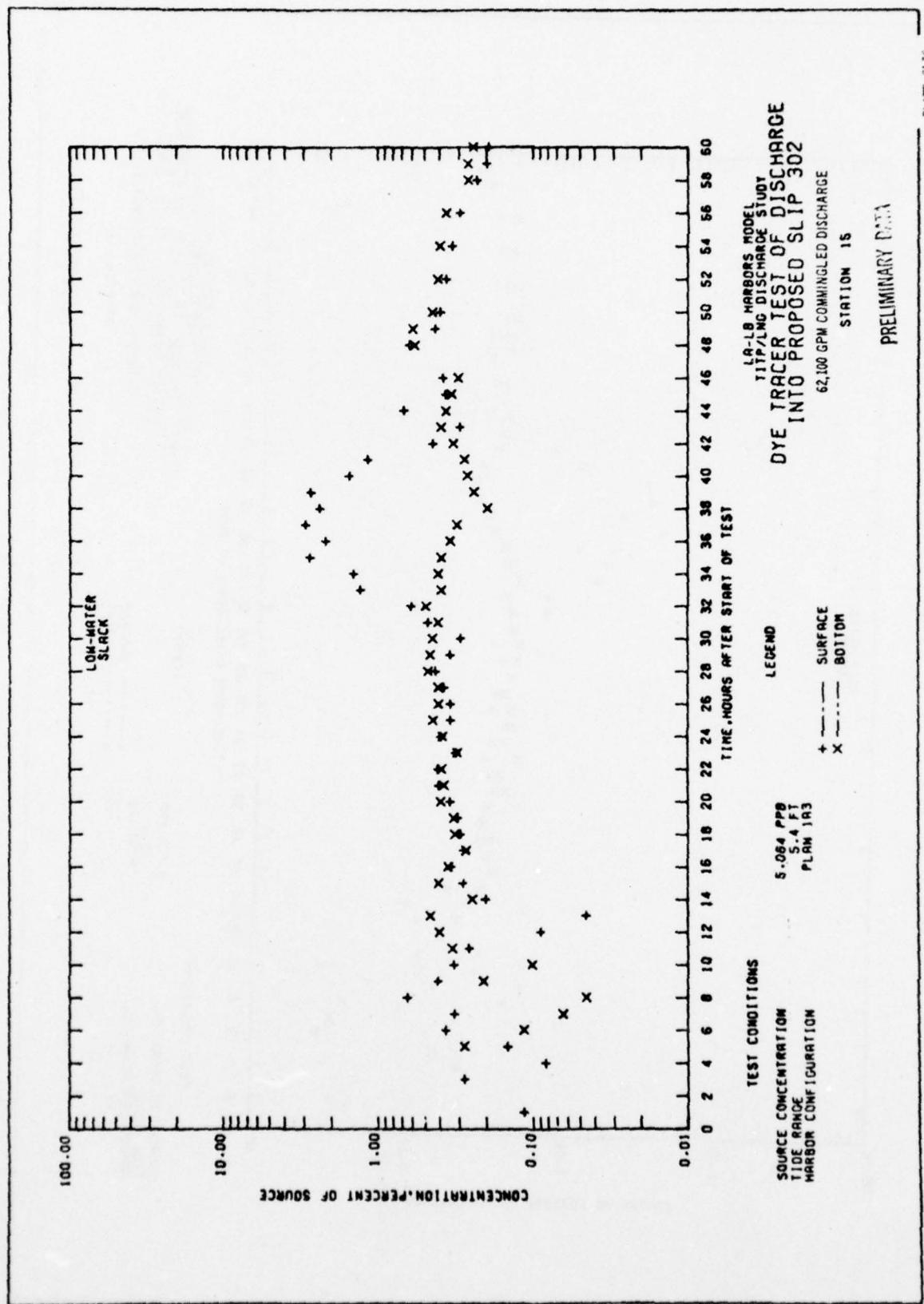
PRELIMINARY DATA

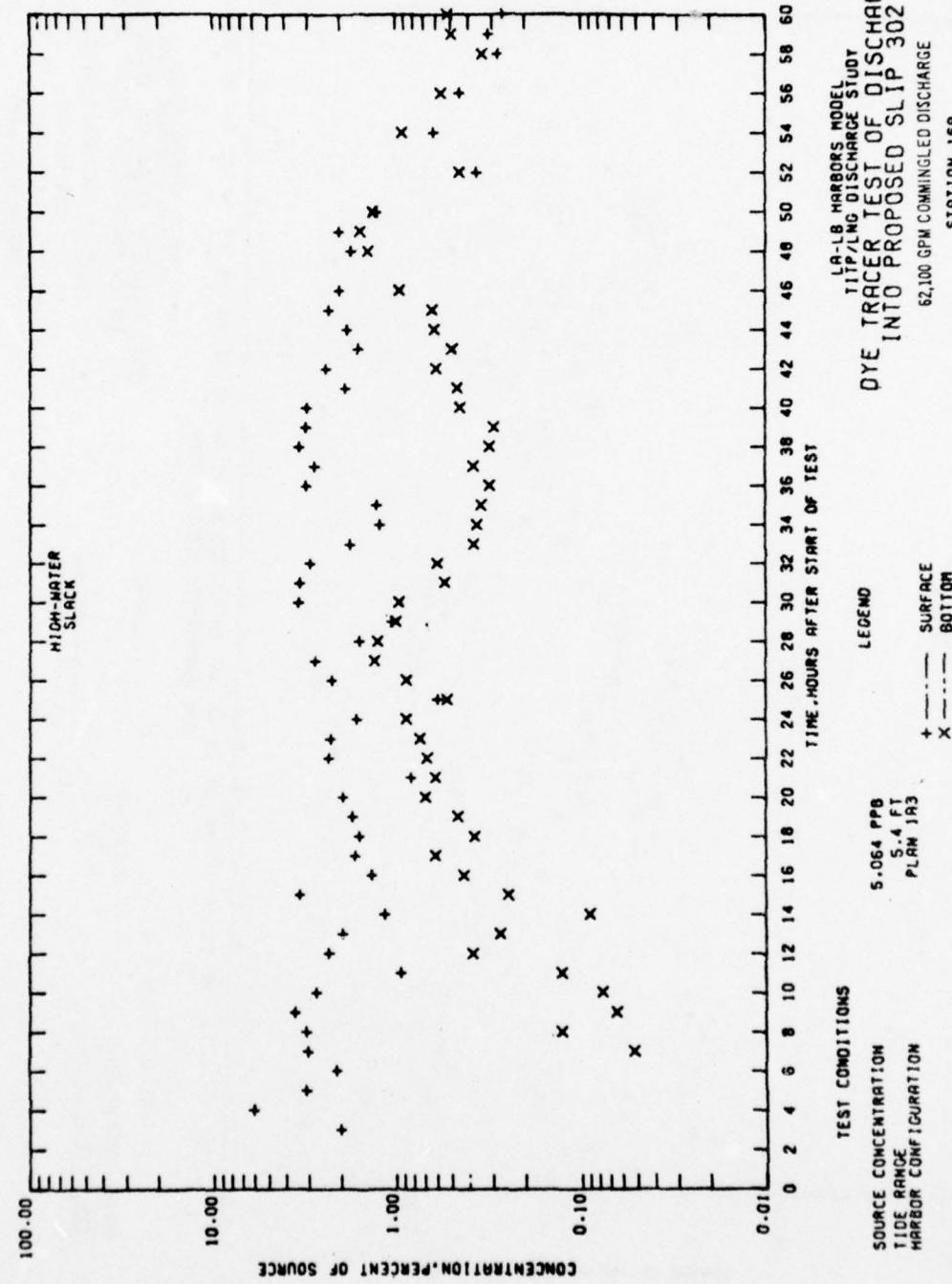
PLATE SL34

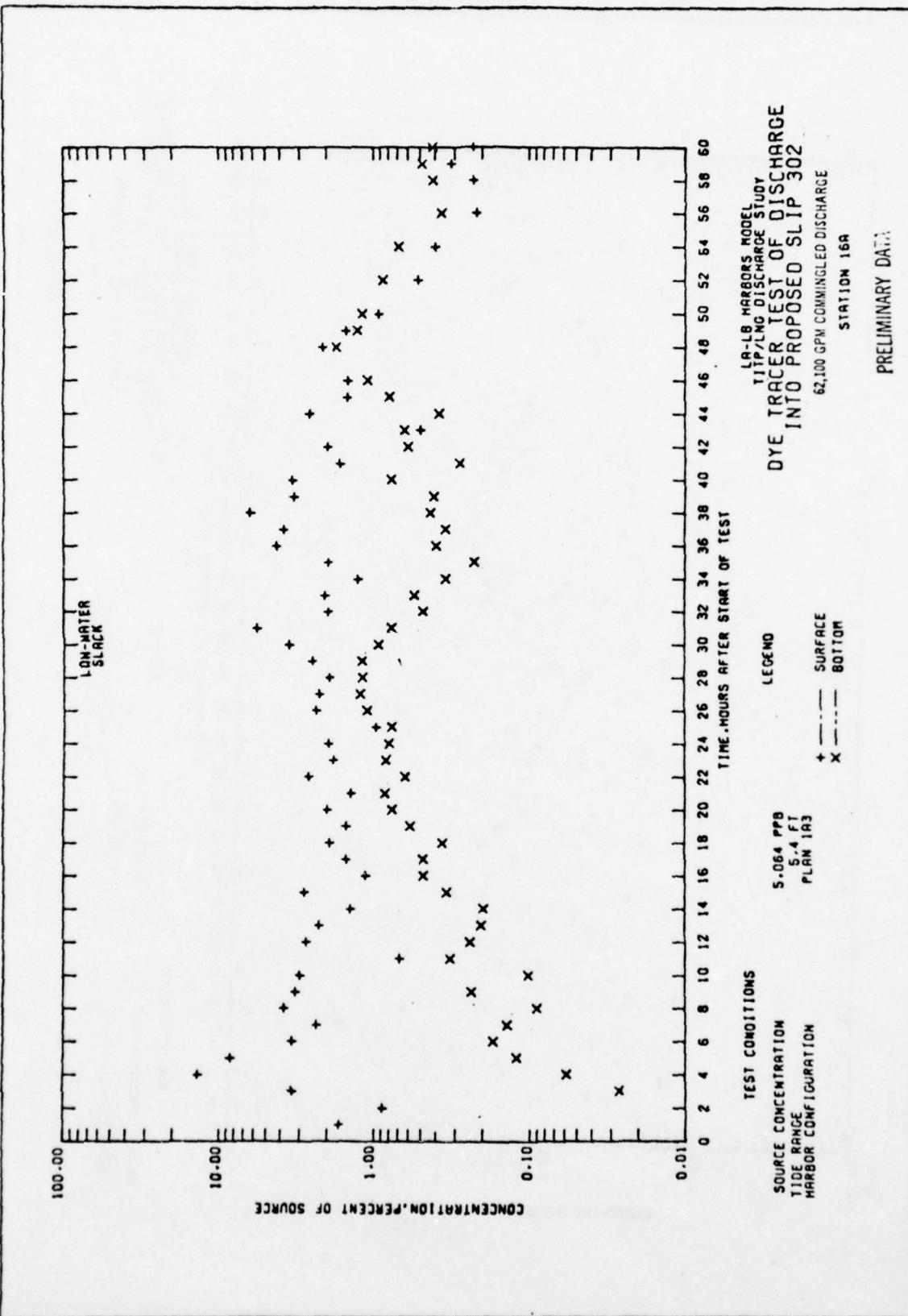


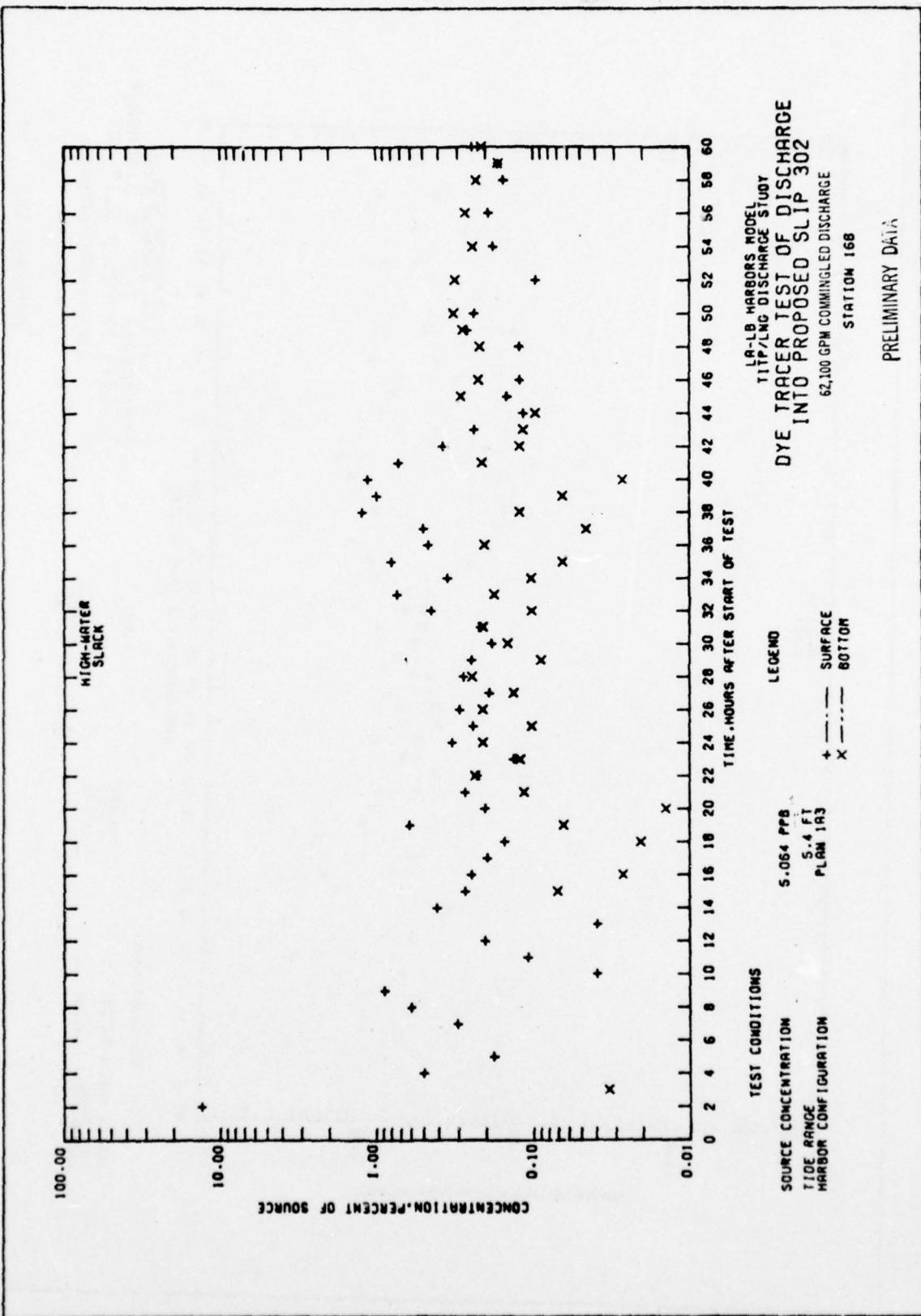


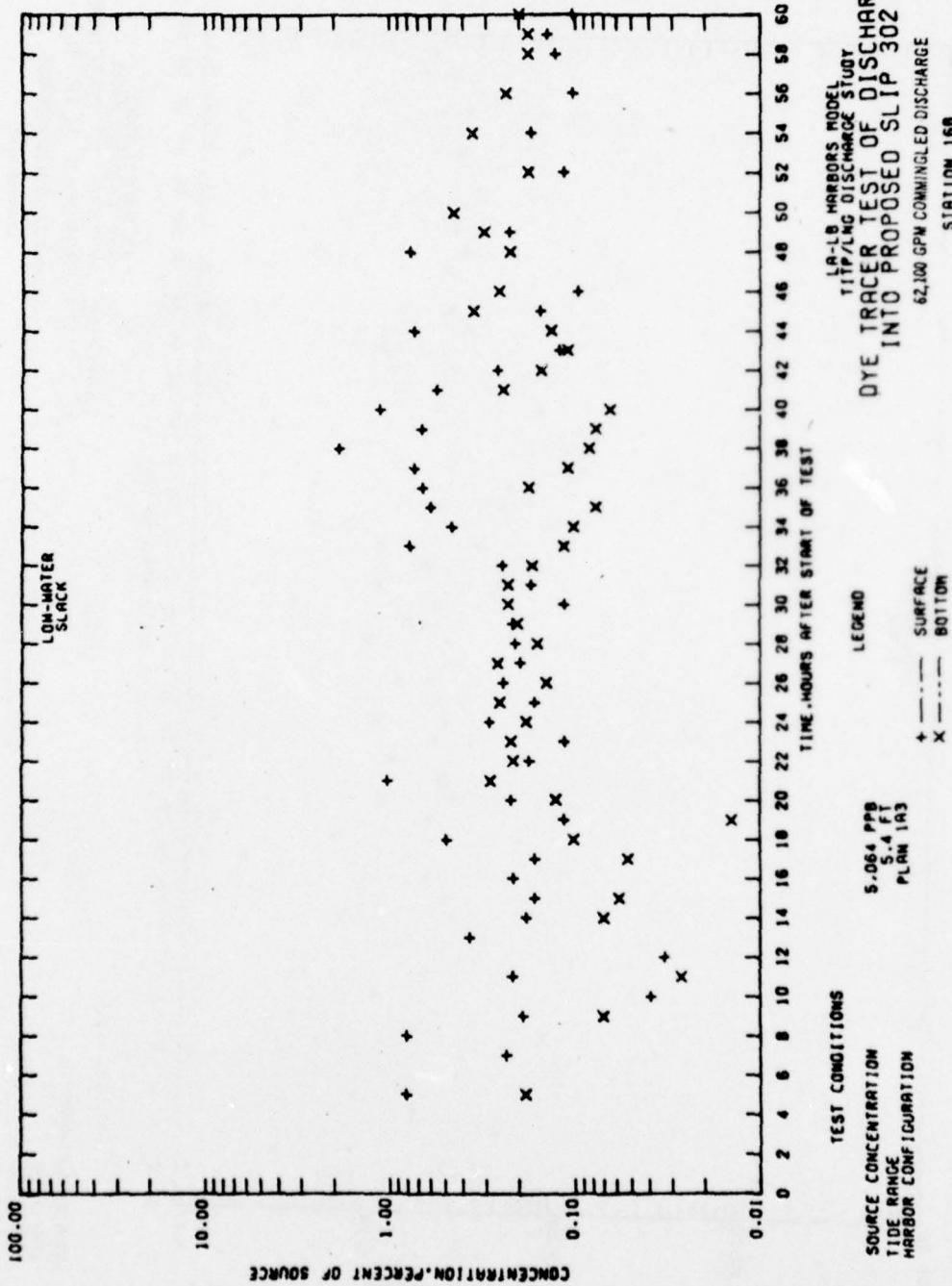


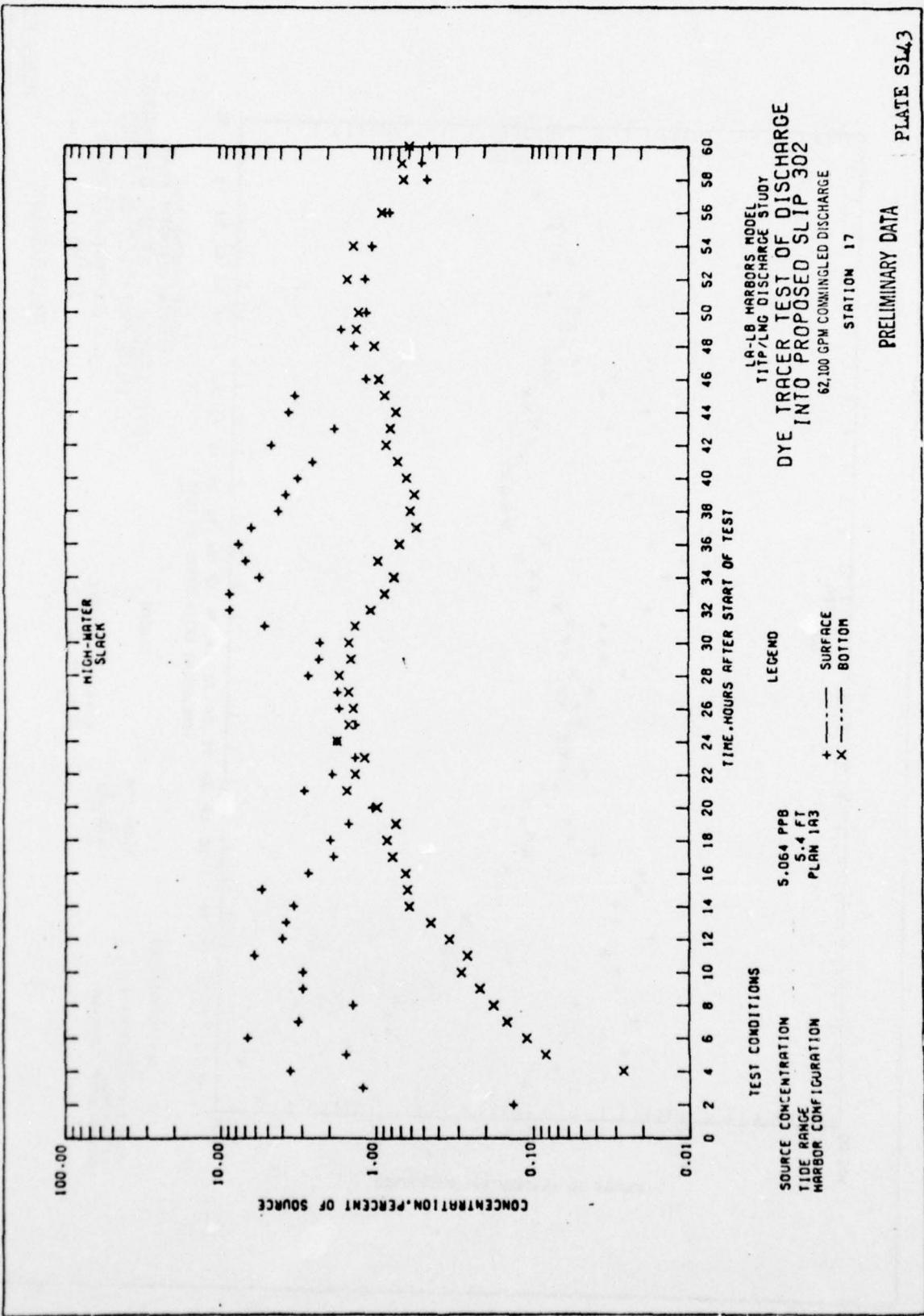












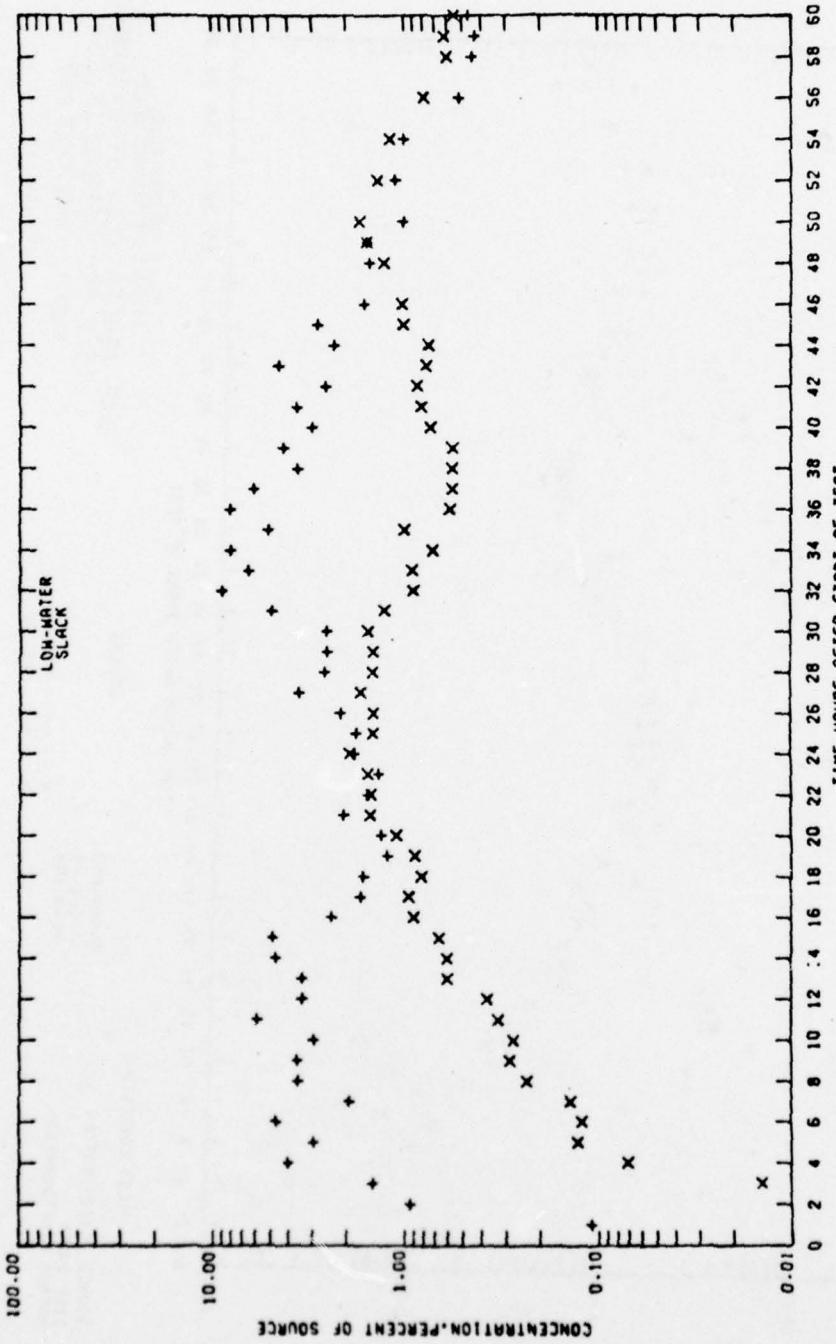
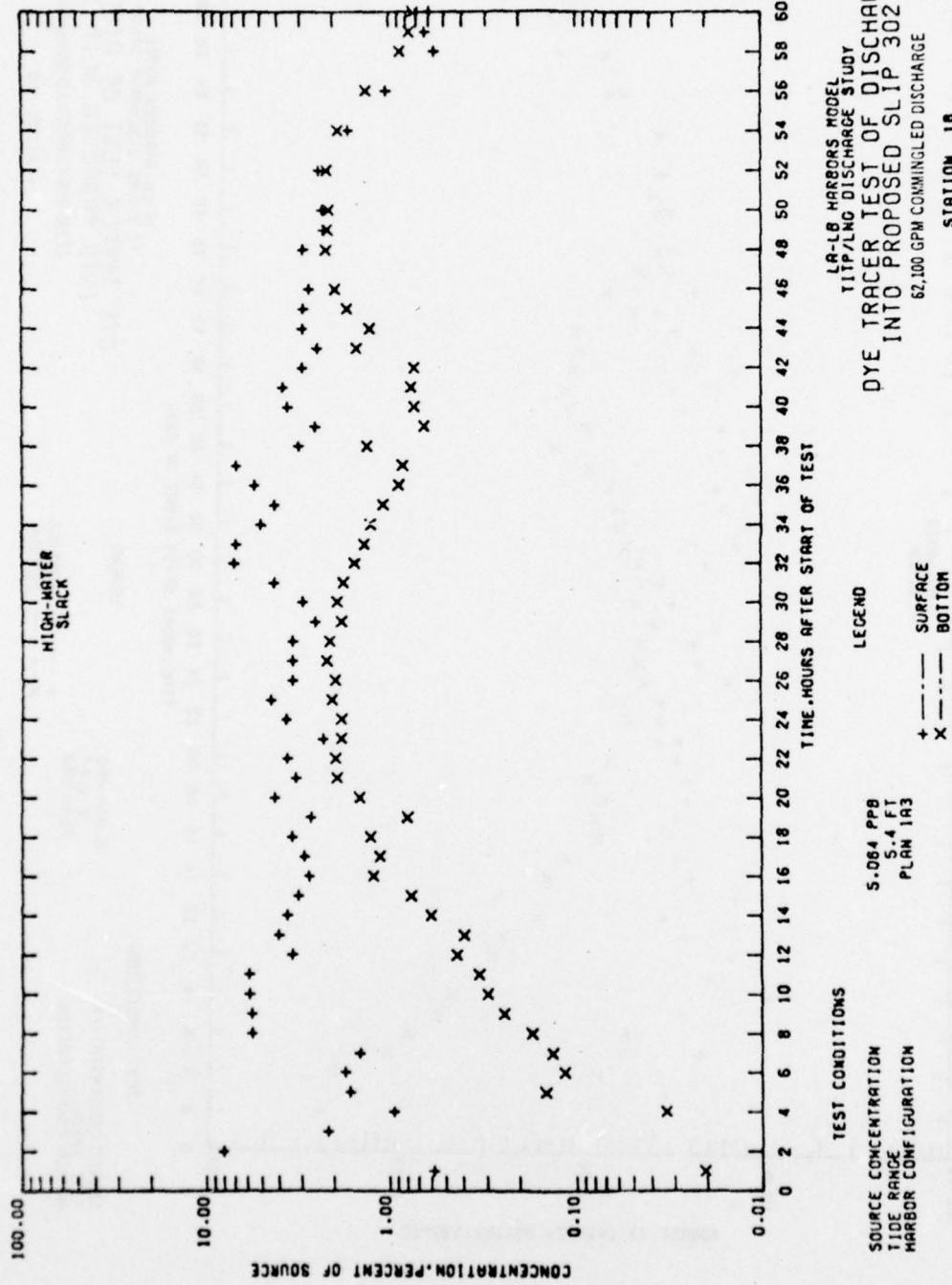
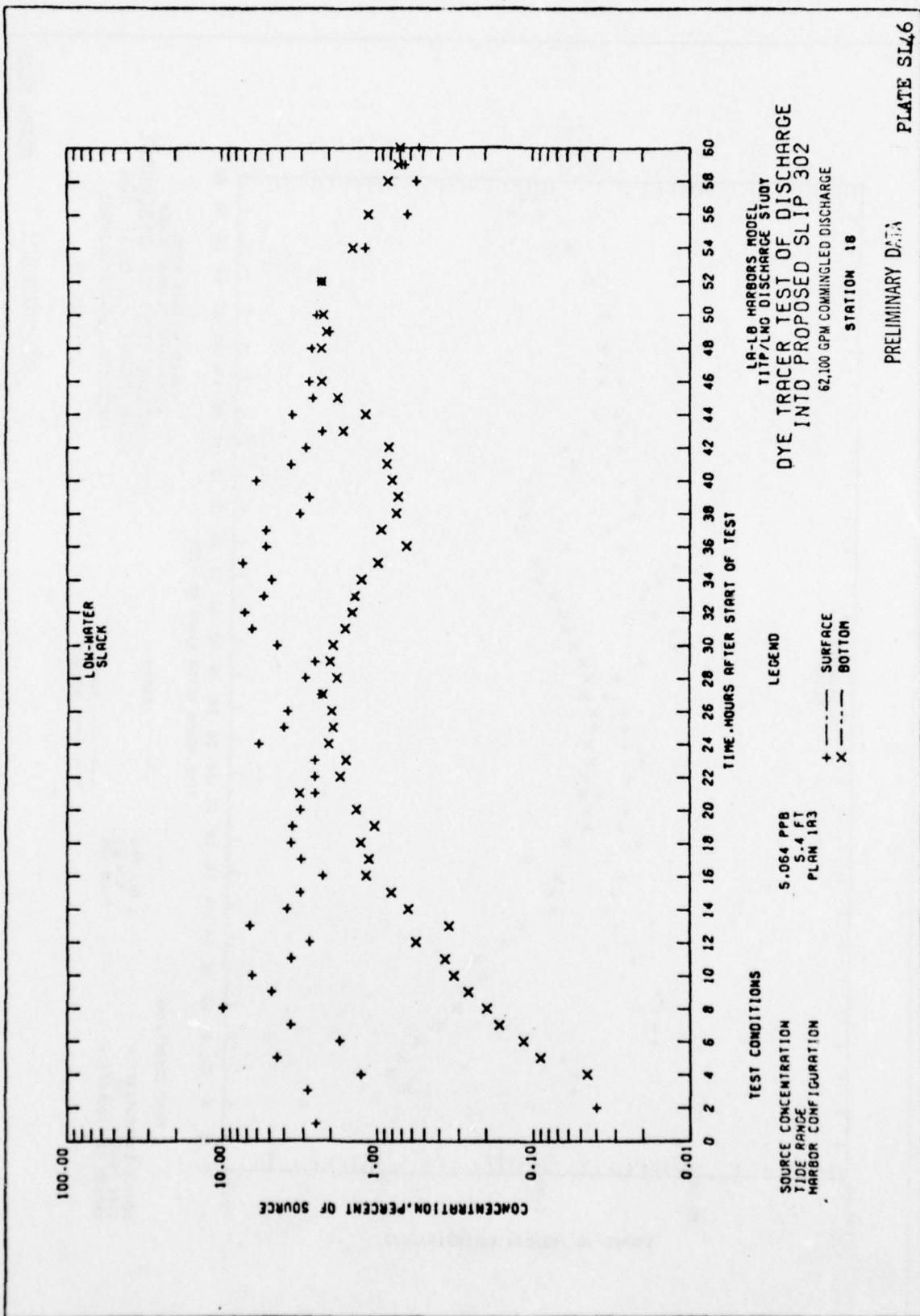
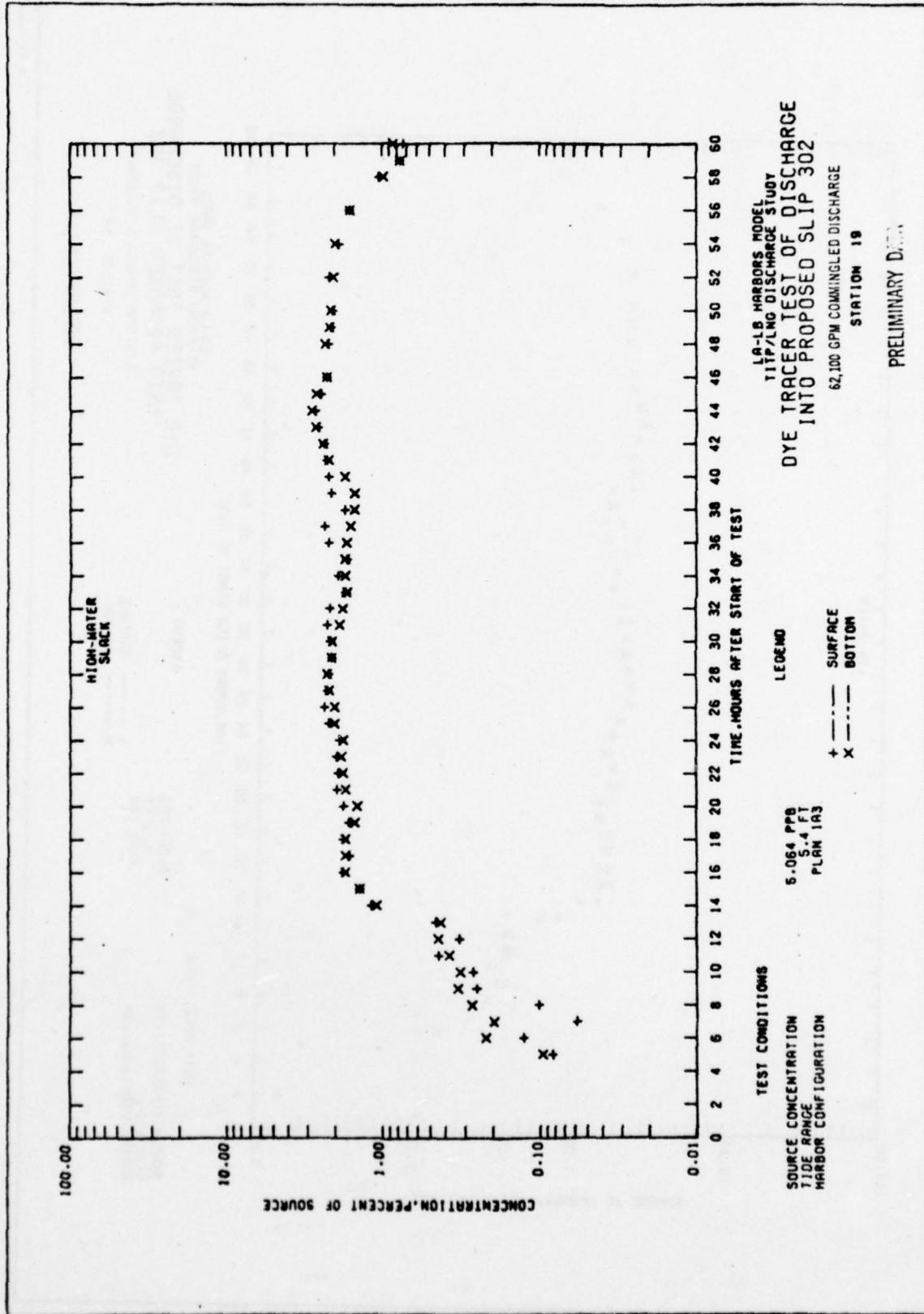
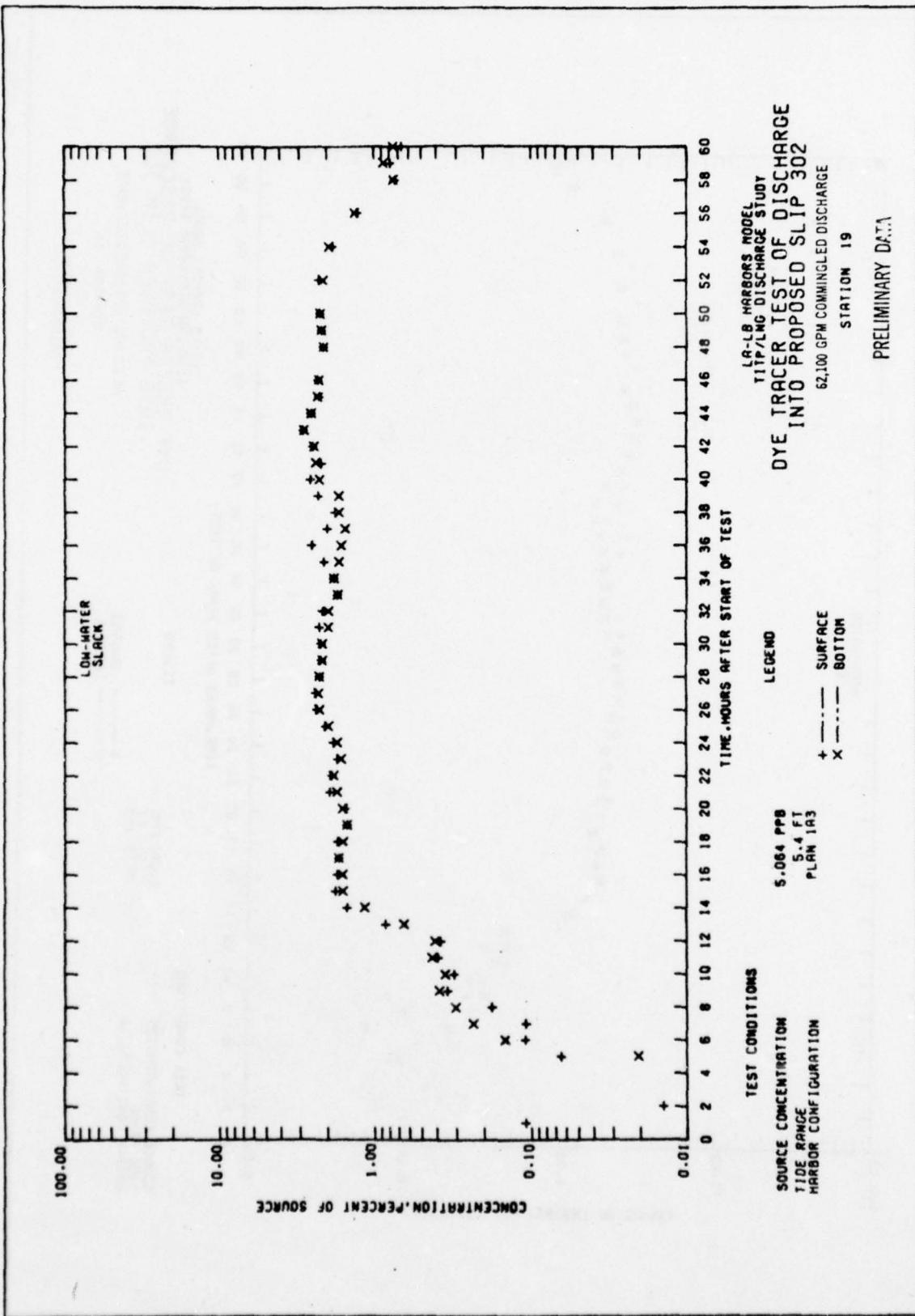


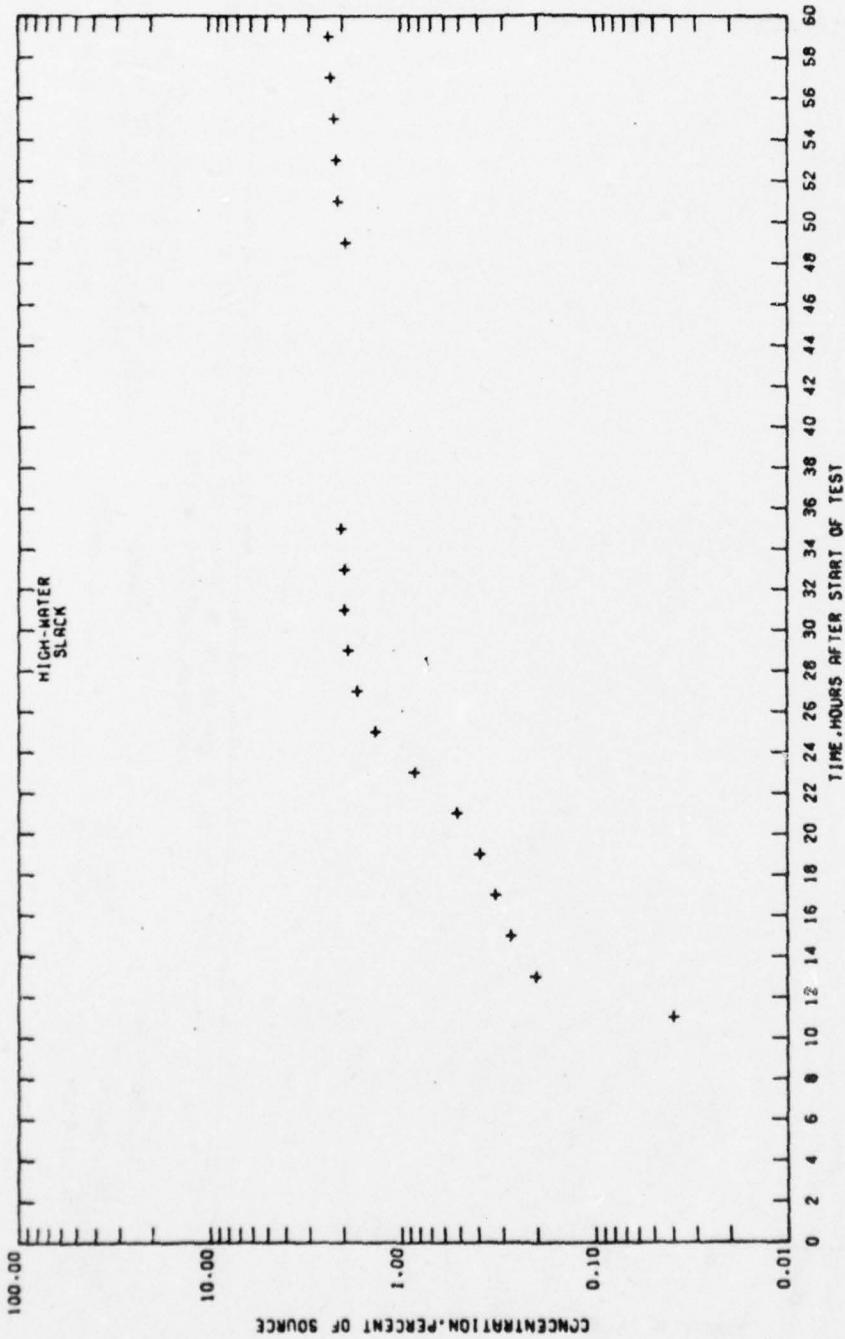
PLATE SL4









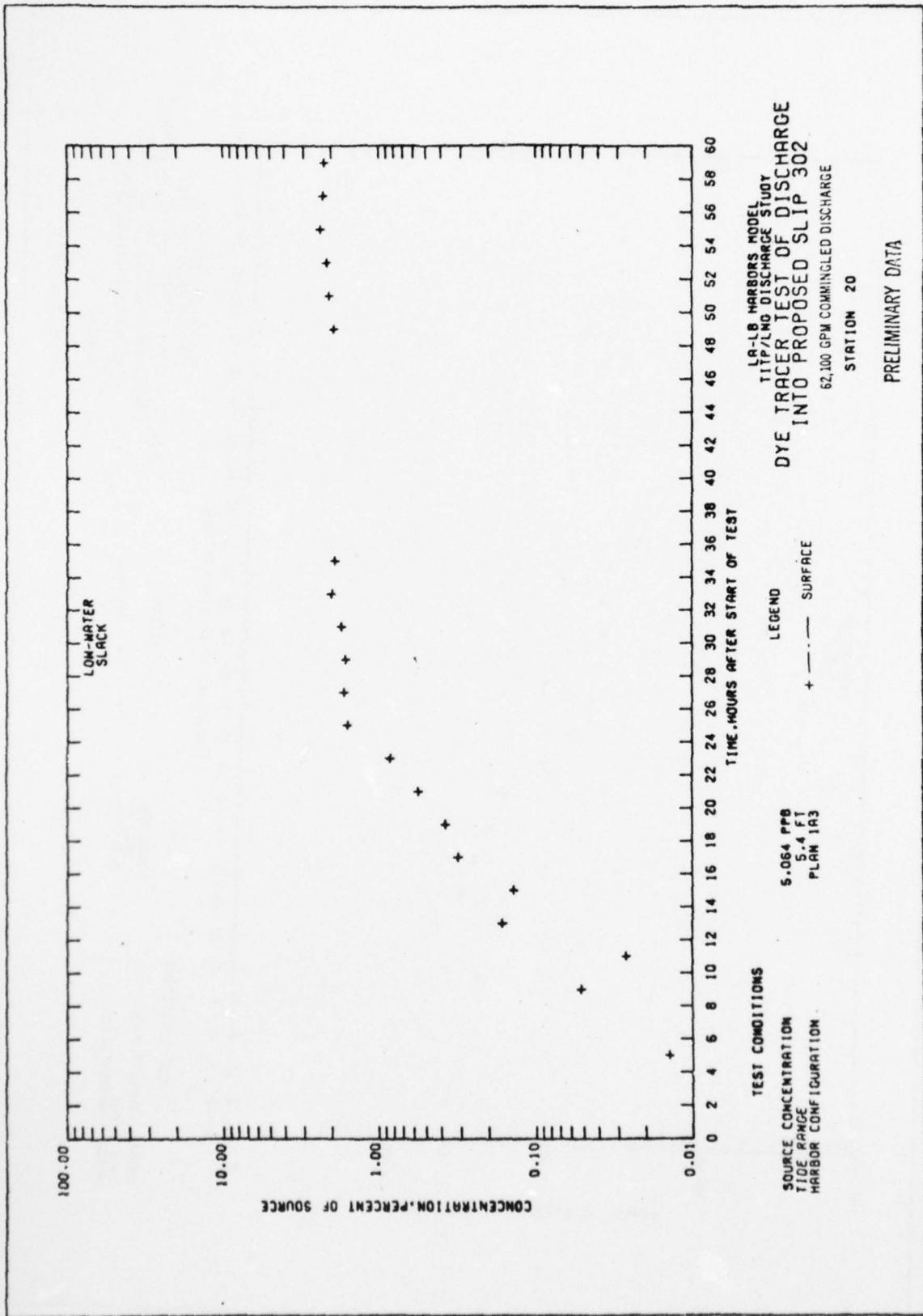


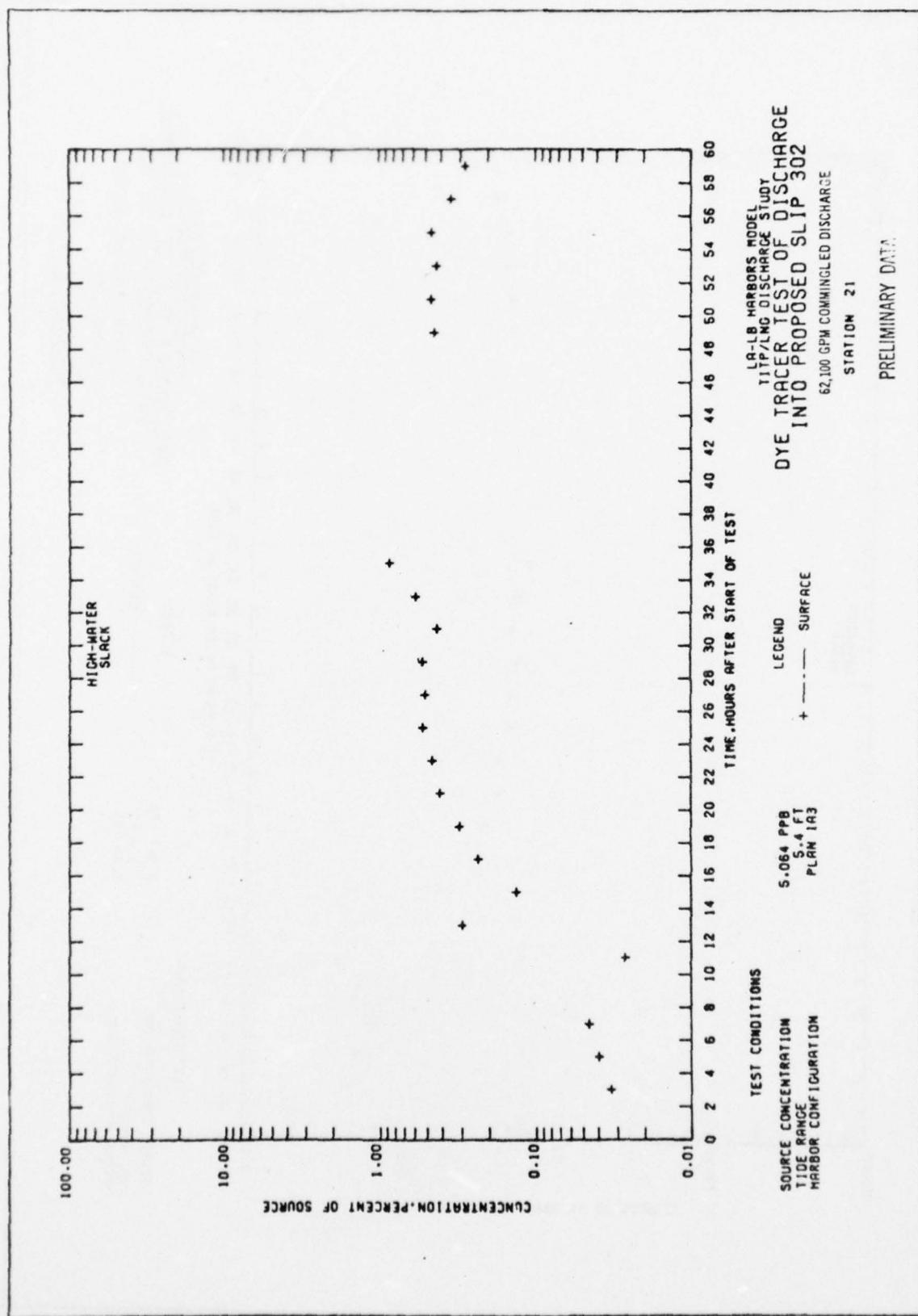
LALB HARBOURS MODEL
TRIPPING DISCHARGE STUDY
DYE TRACER TEST OF DISCHARGE
INTO PROPOSED SLIP 302

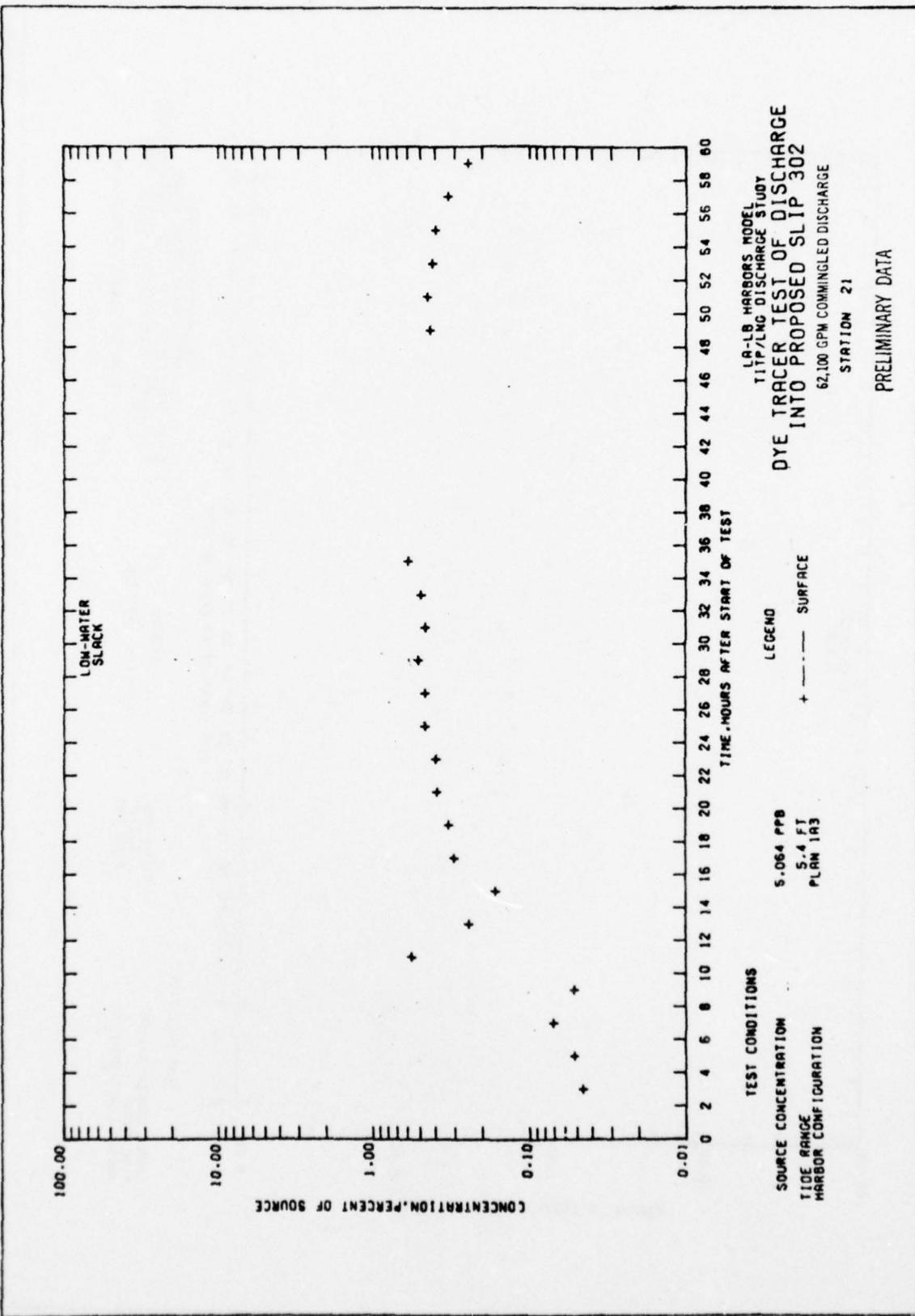
62,100 GPM COMMINGLED DISCHARGE
STATION 20

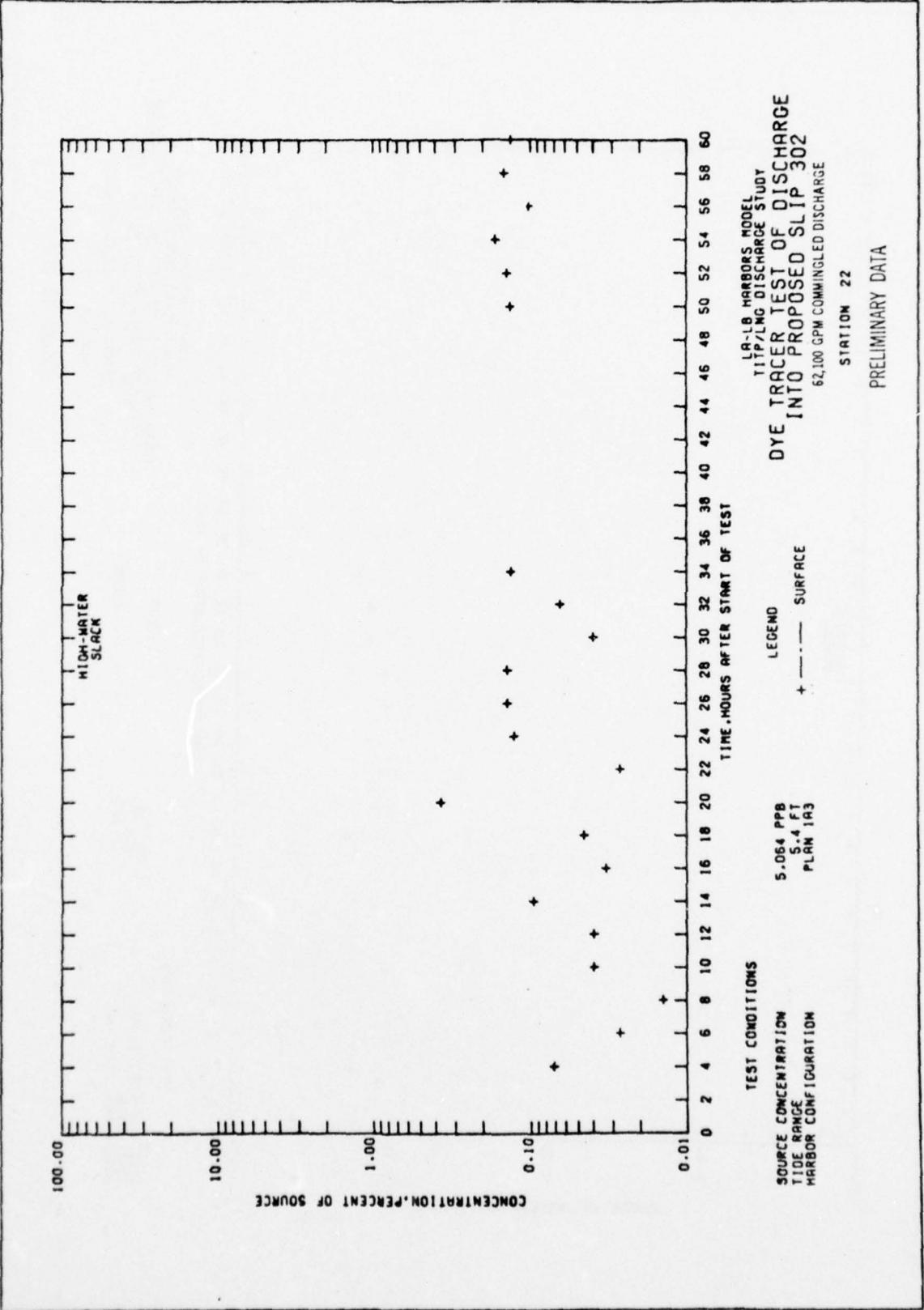
PRELIMINARY DATA

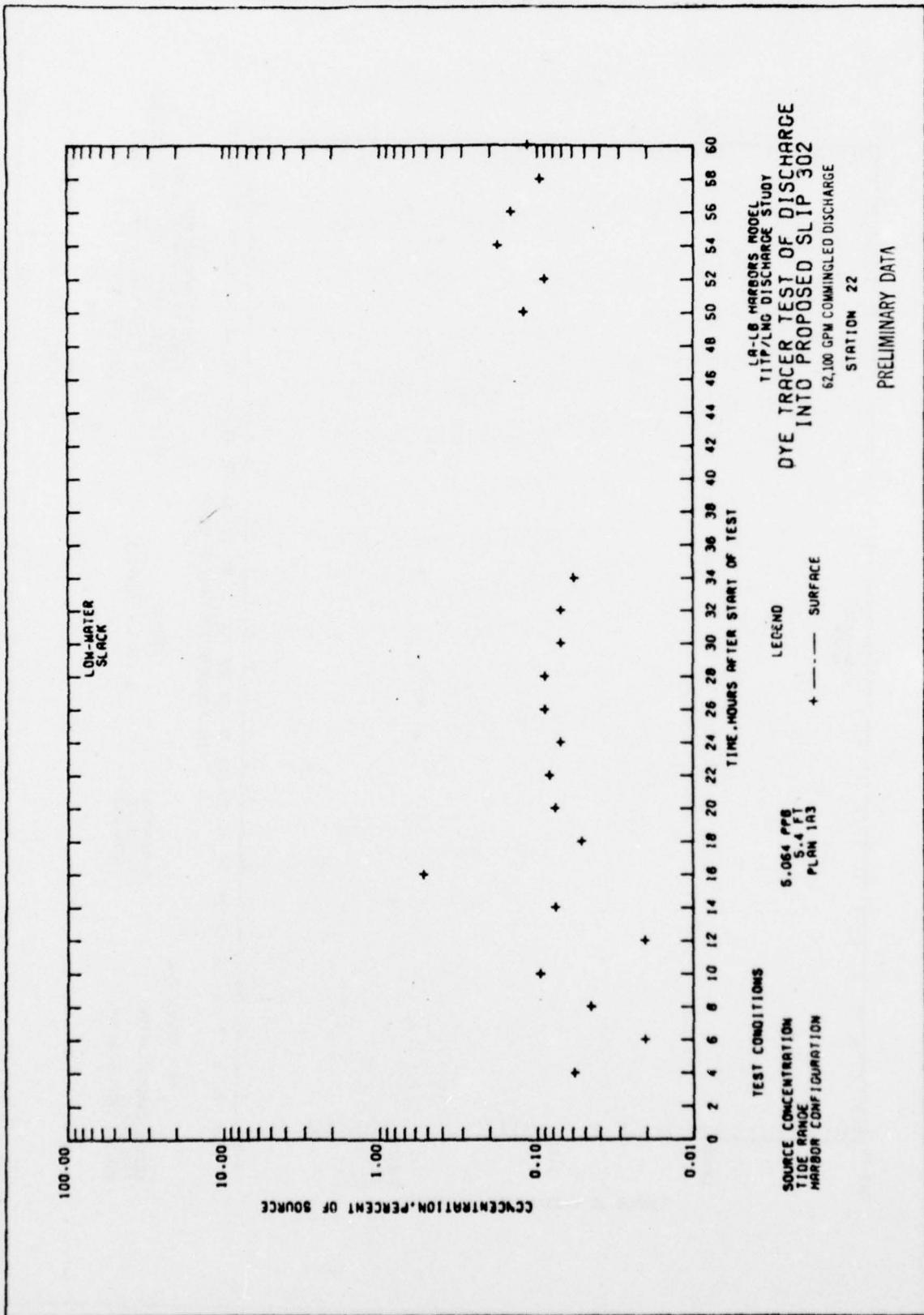
TEST CONDITIONS
SOURCE CONCENTRATION 5.064 PPB
TIDE RANGE 5.4 FT
HARBOR CONFIGURATION PLAN 1A3
+ — — SURFACE

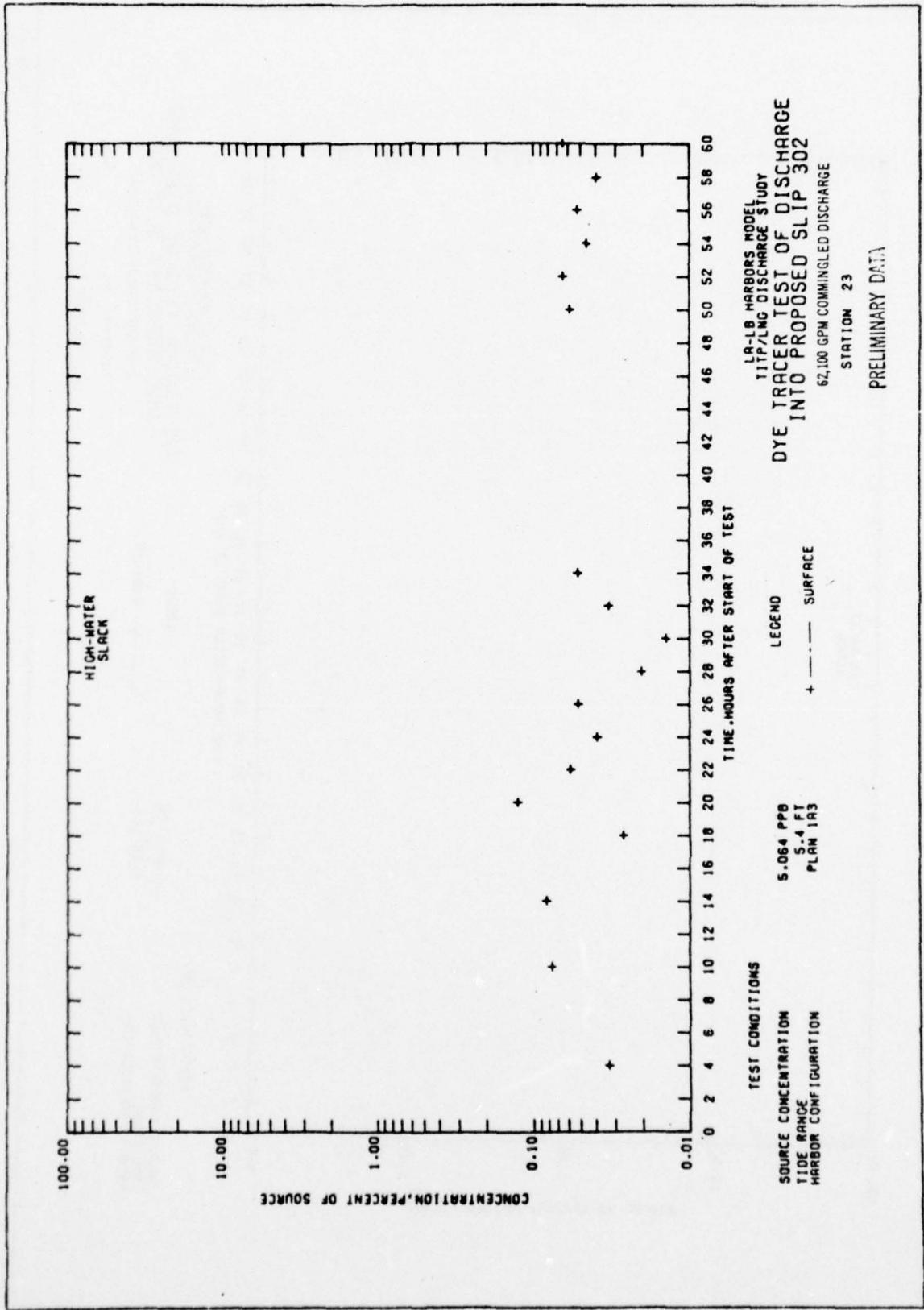


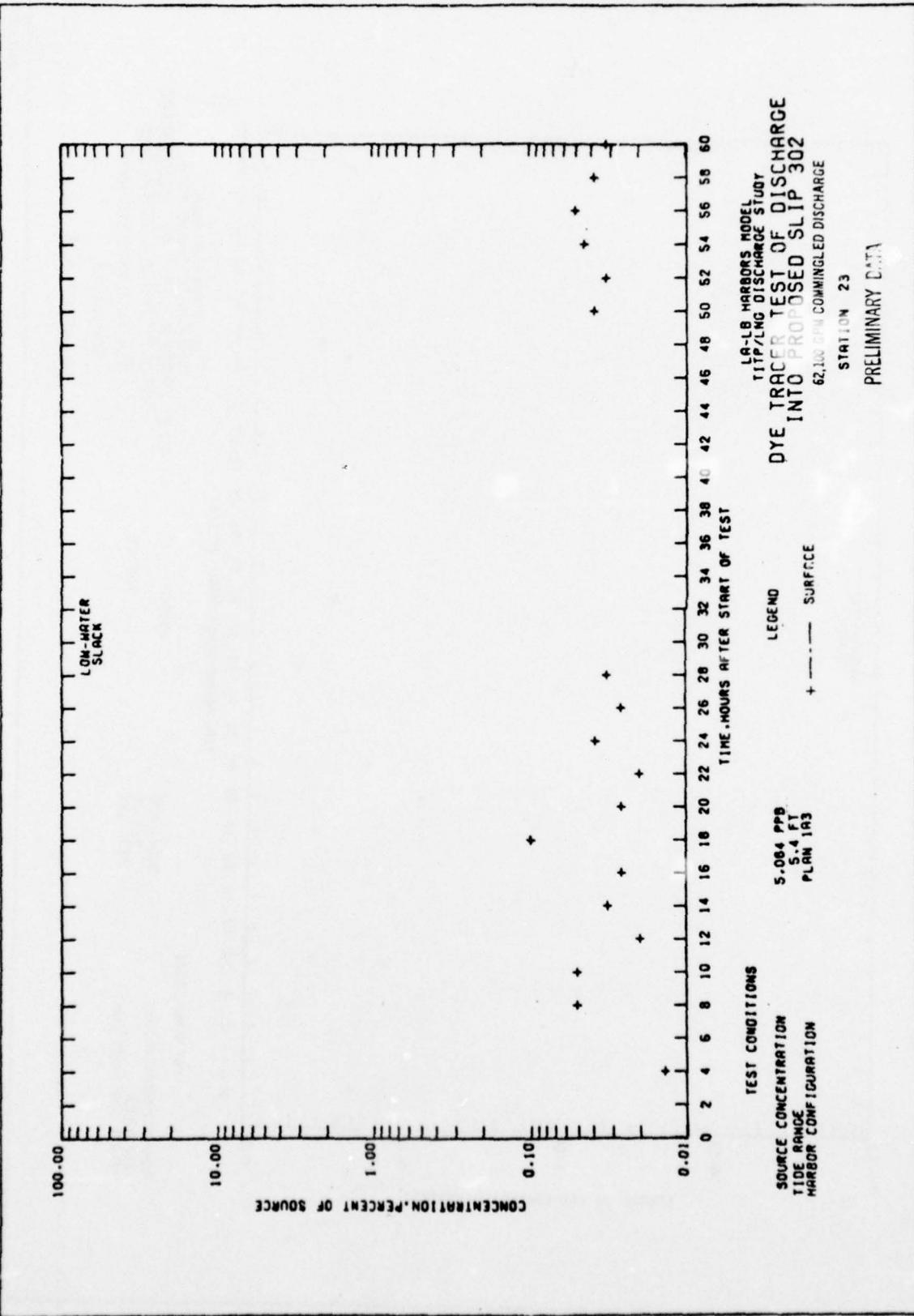


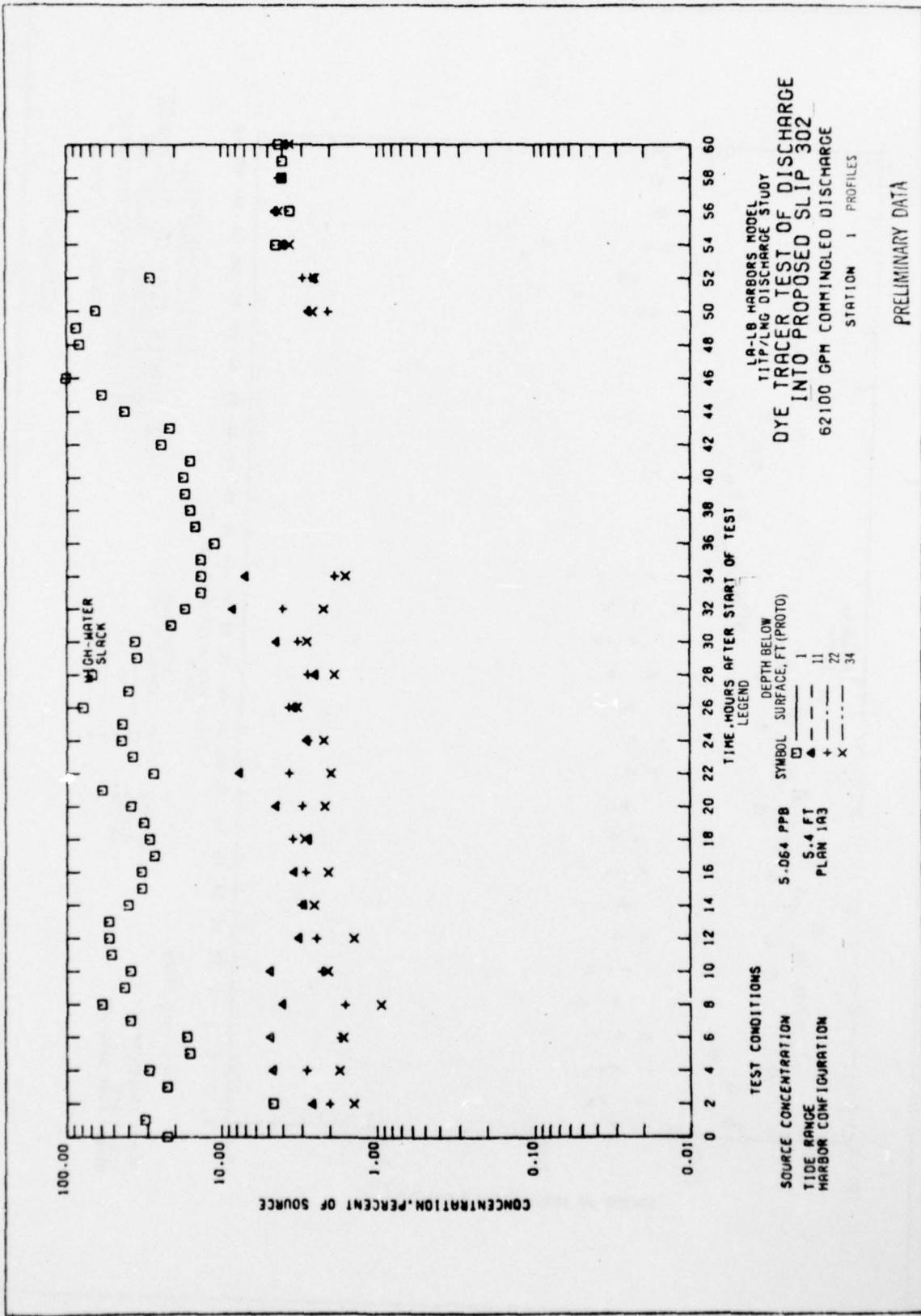


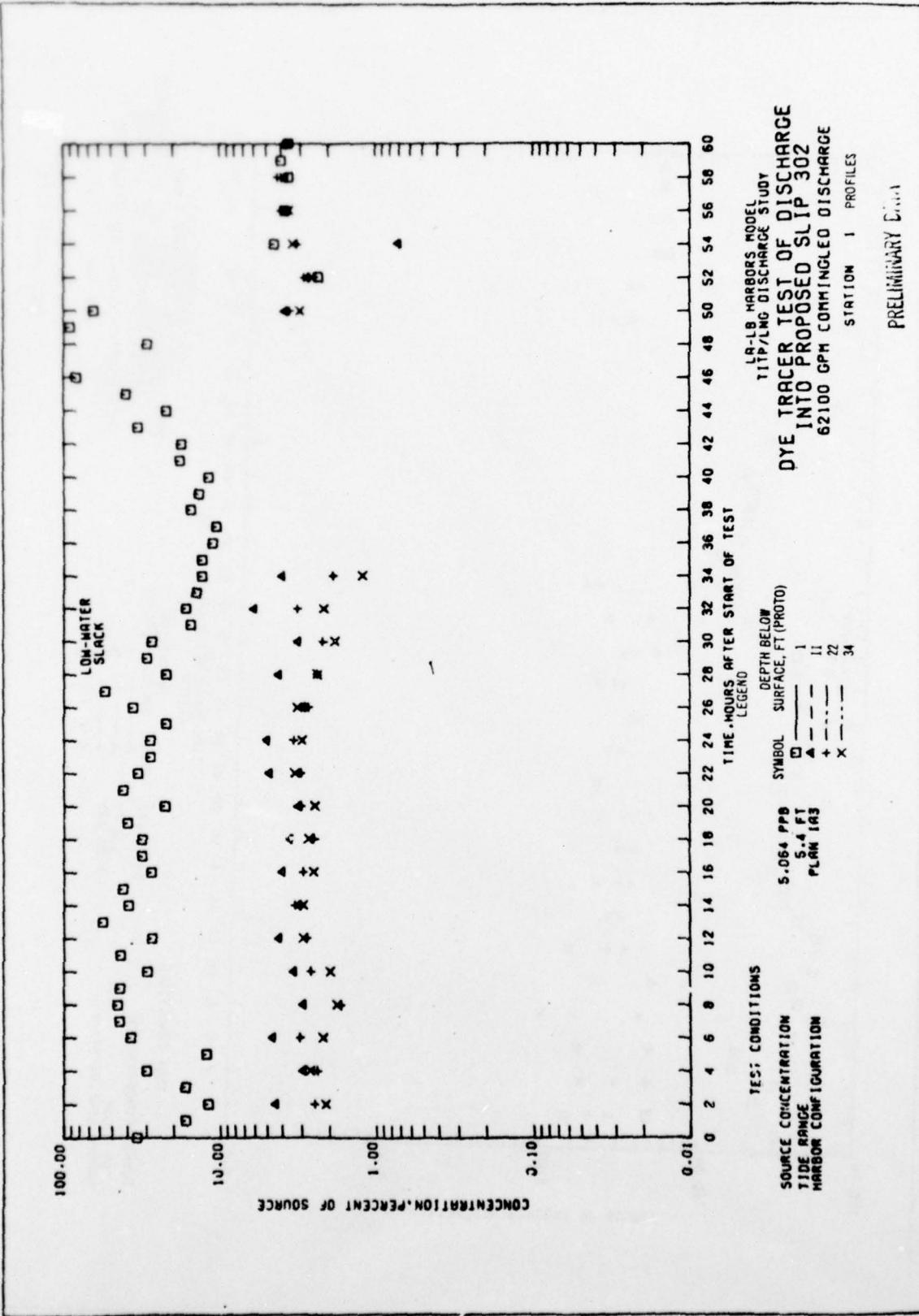


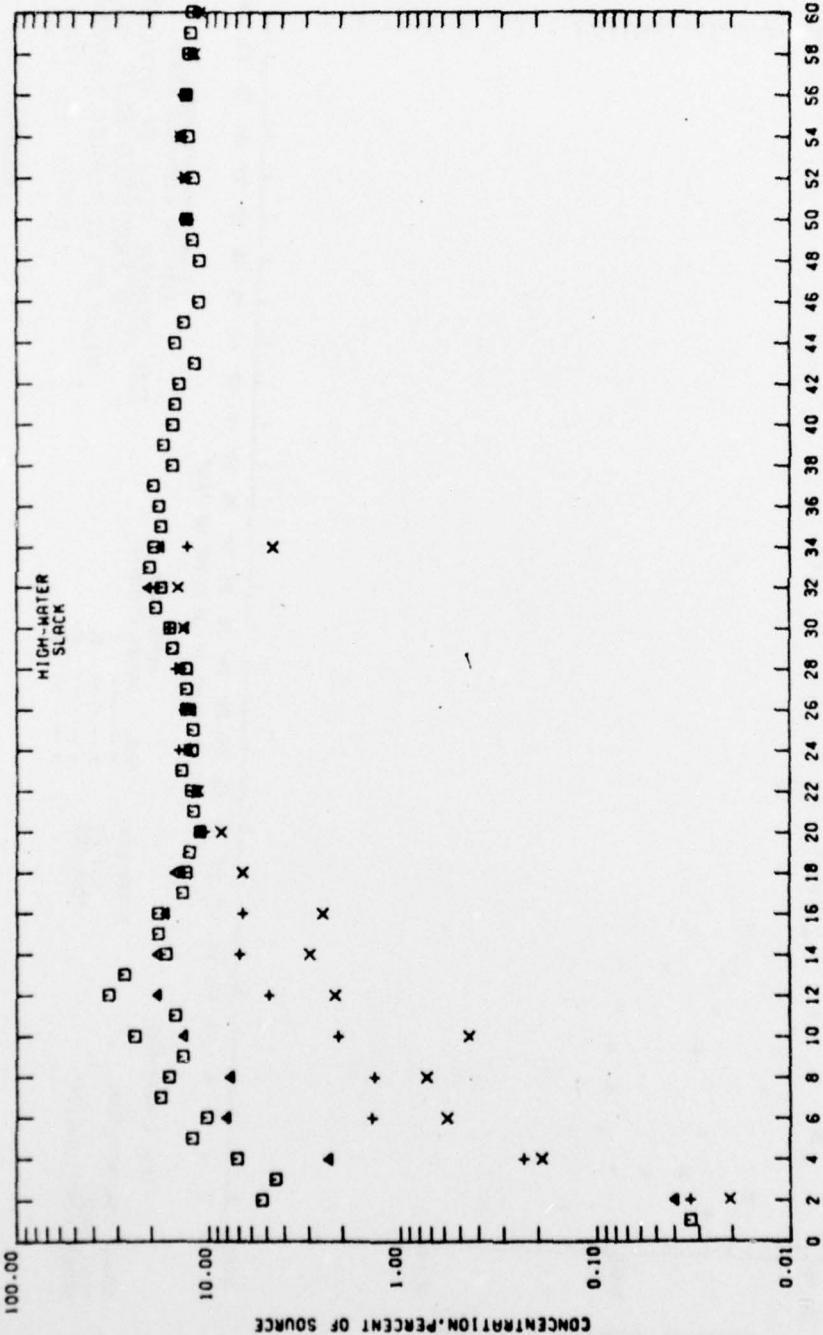








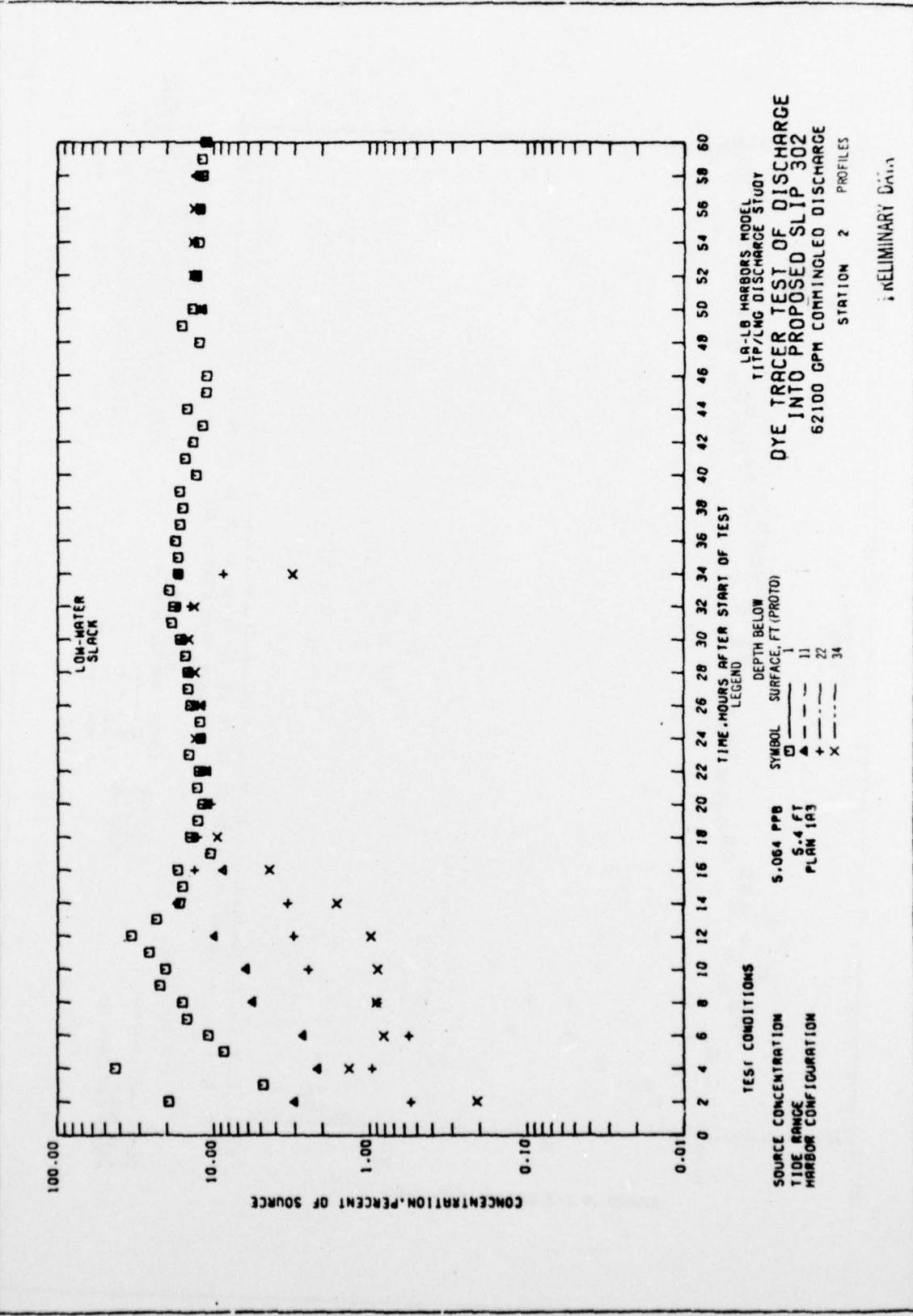


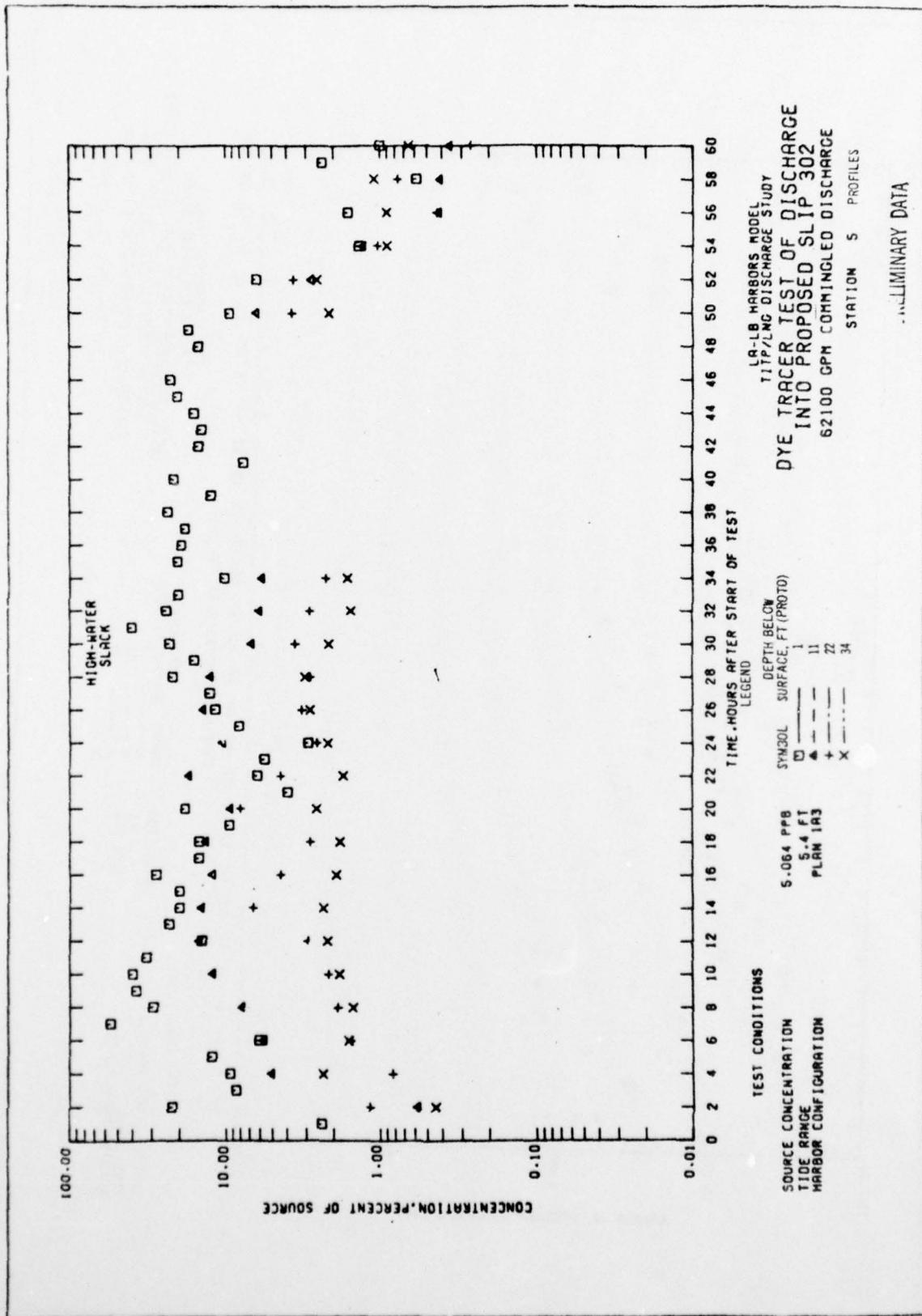


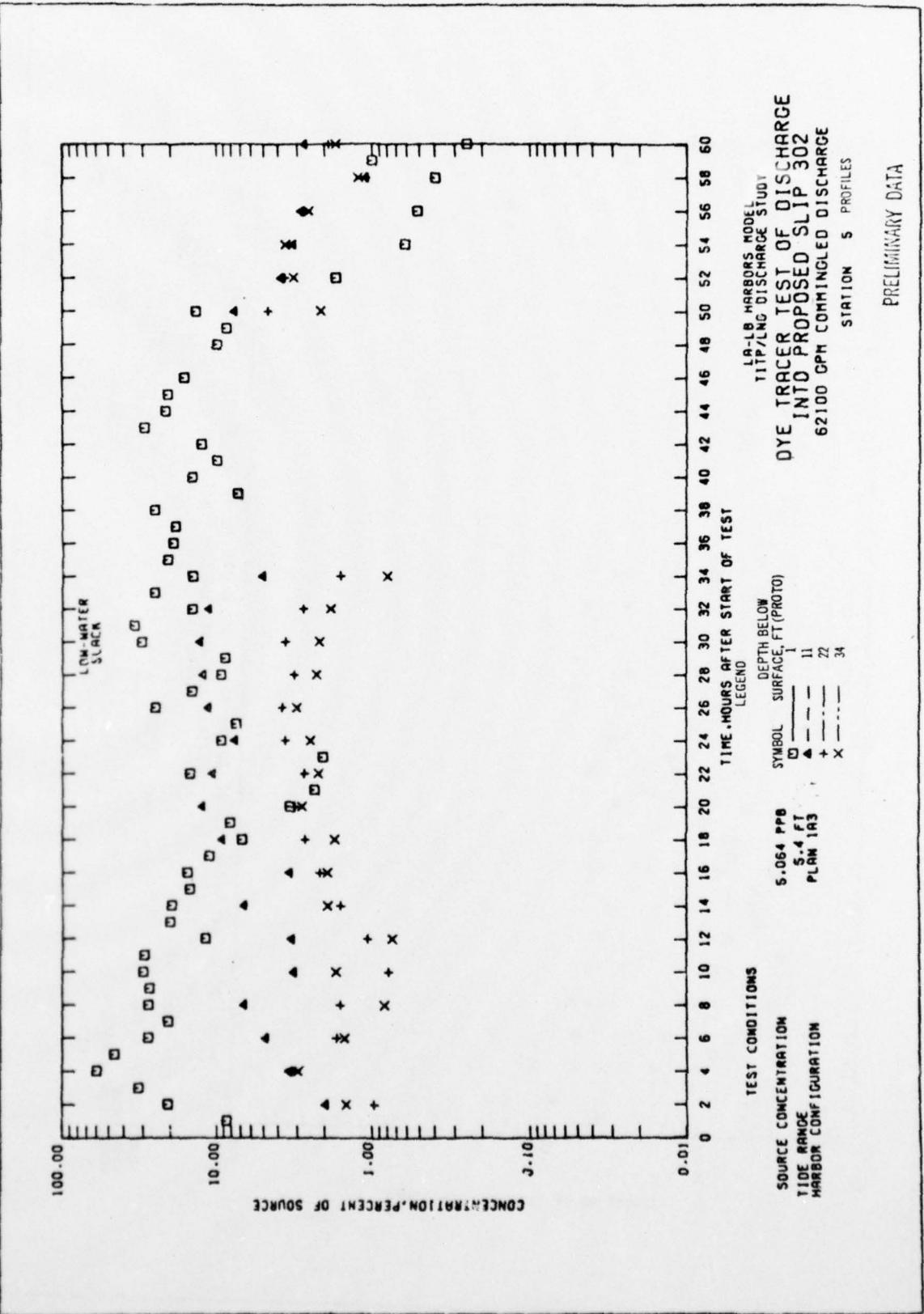
LPG-LB HARBOURS MODEL
TIP/LNG DISCHARGE STUDY
DYE TRACER TEST OF DISCHARGE
INTO PROPOSED SLIP 302
62100 GPM COMMINGLED DISCHARGE
STATION 2 PROFILES

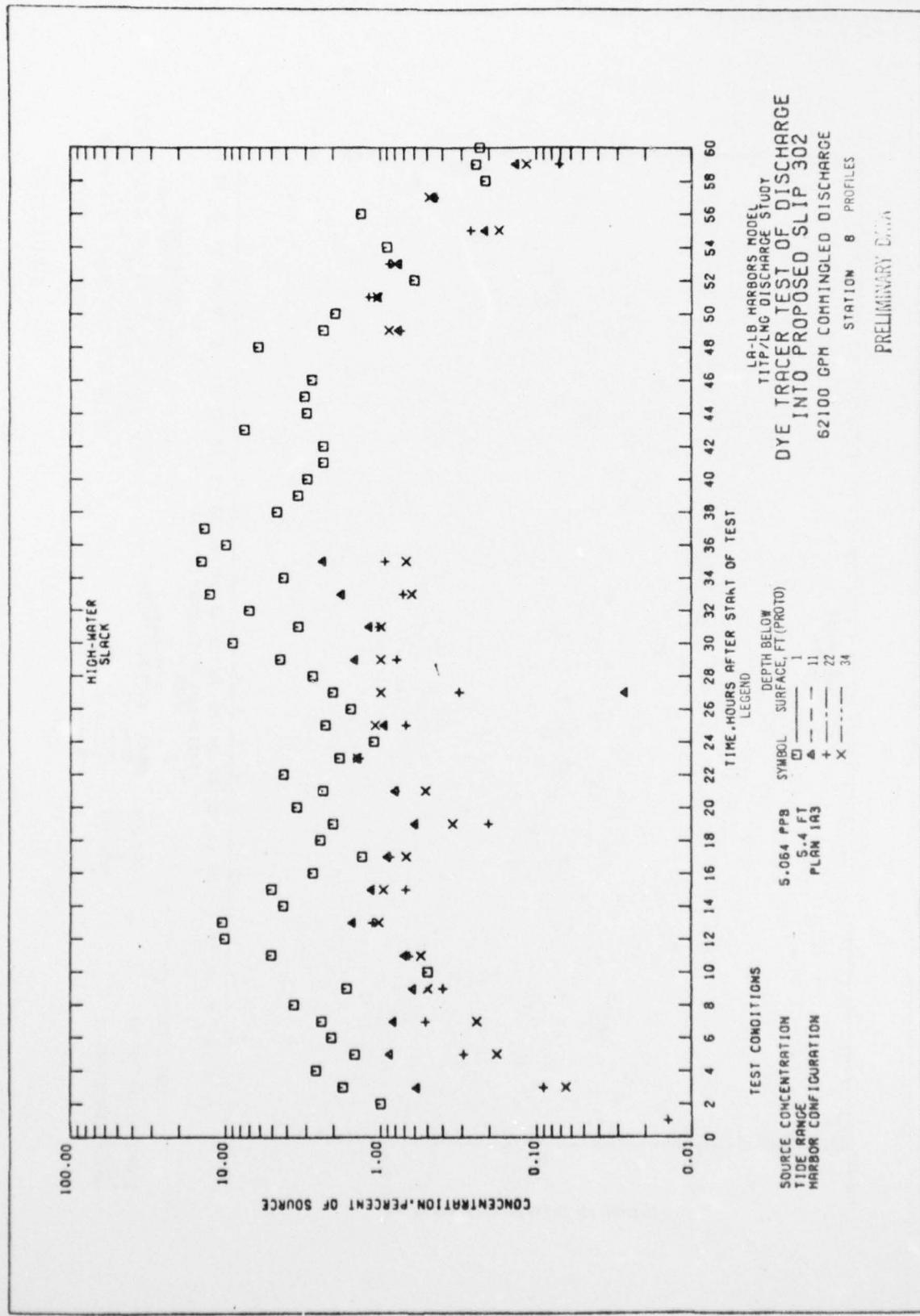
PRELIMINARY DATA

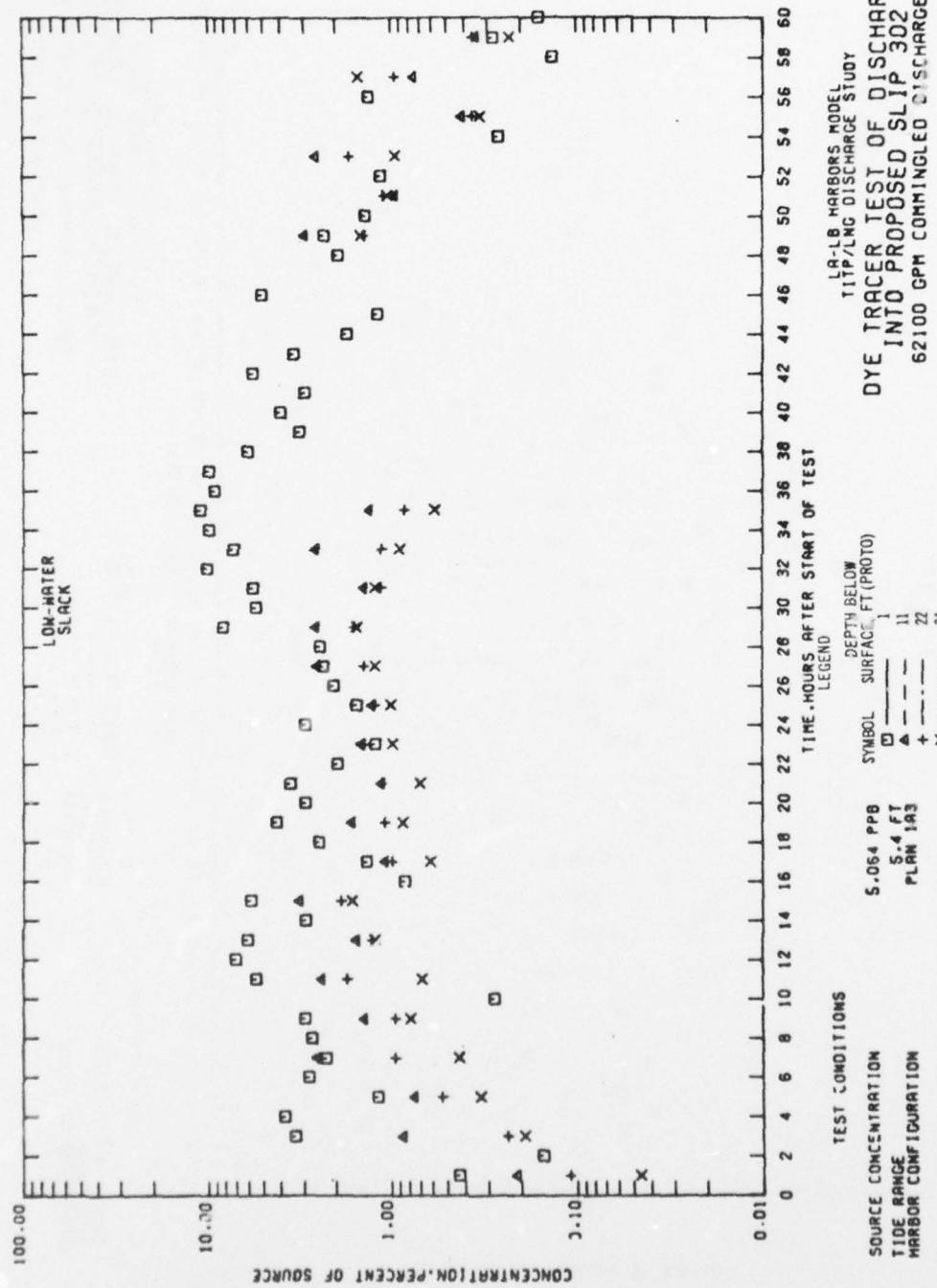
PLATE 2

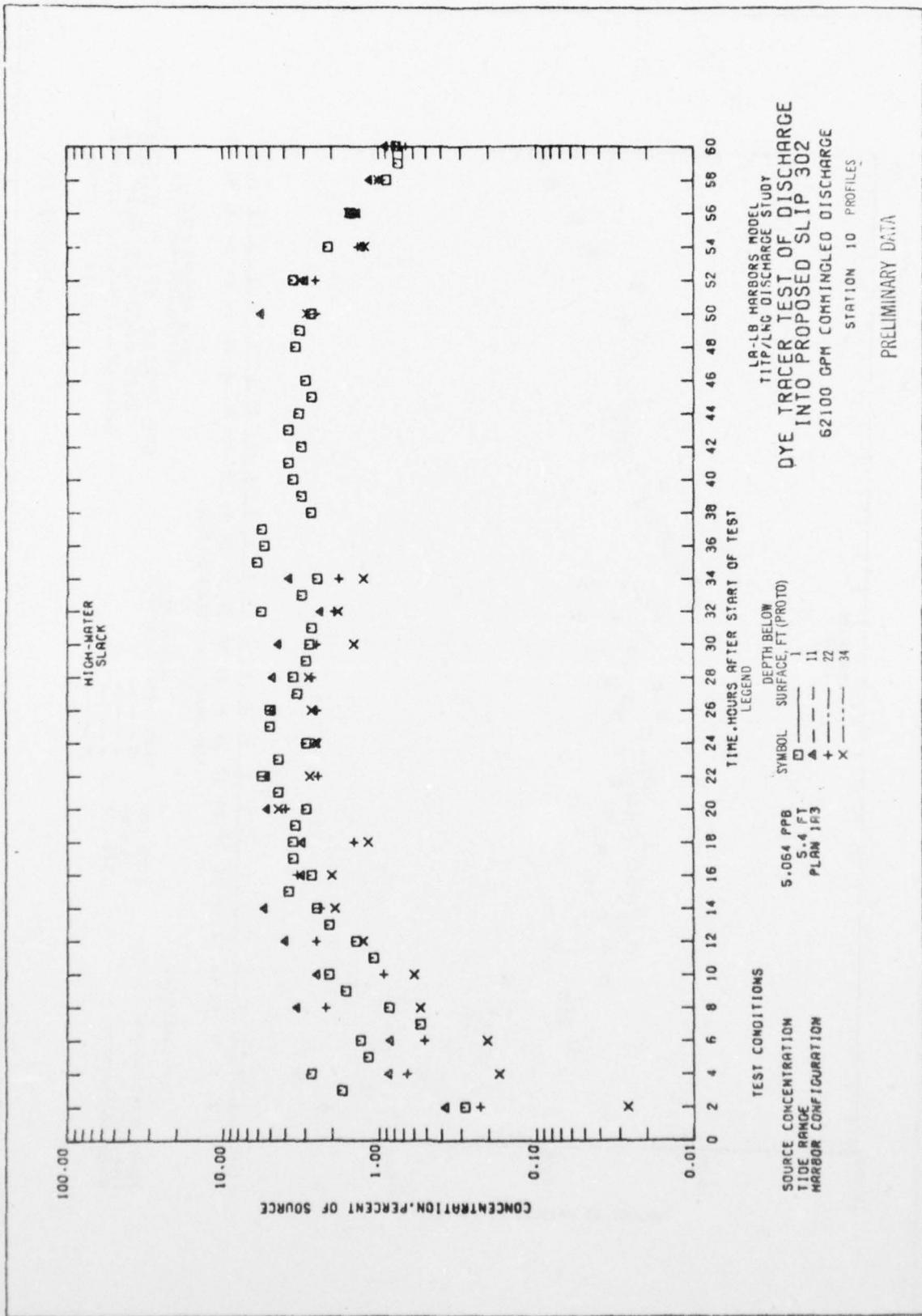


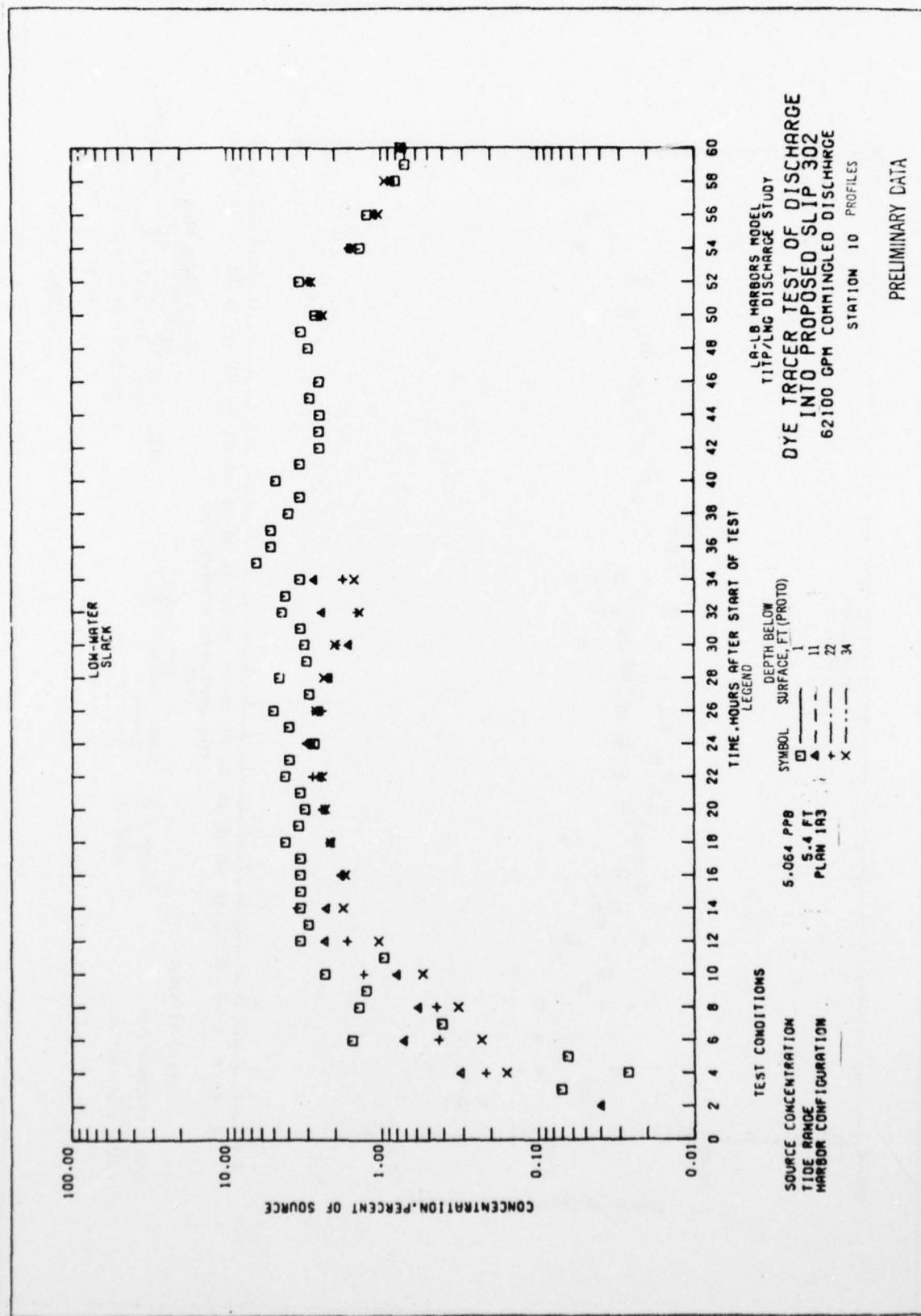


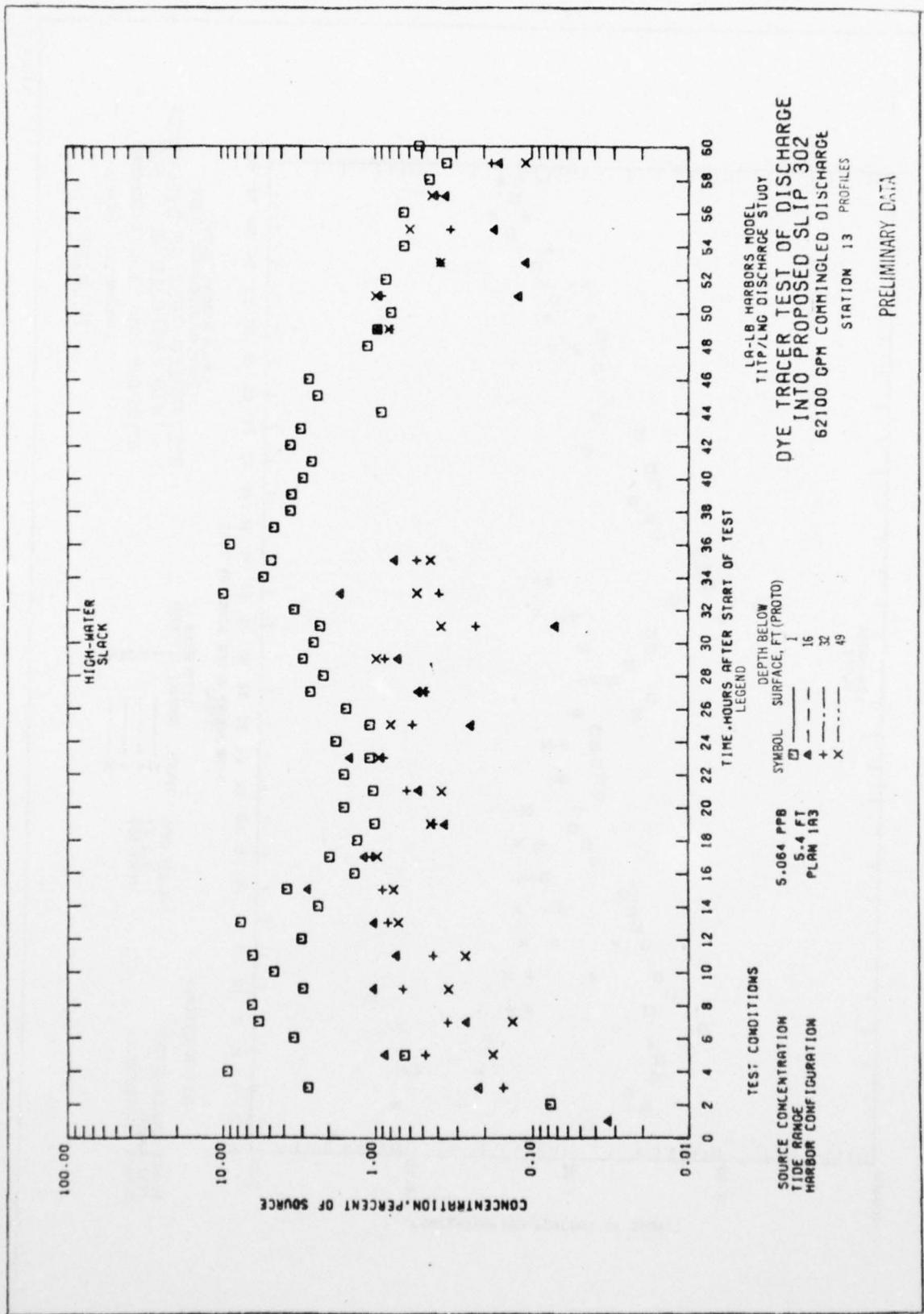


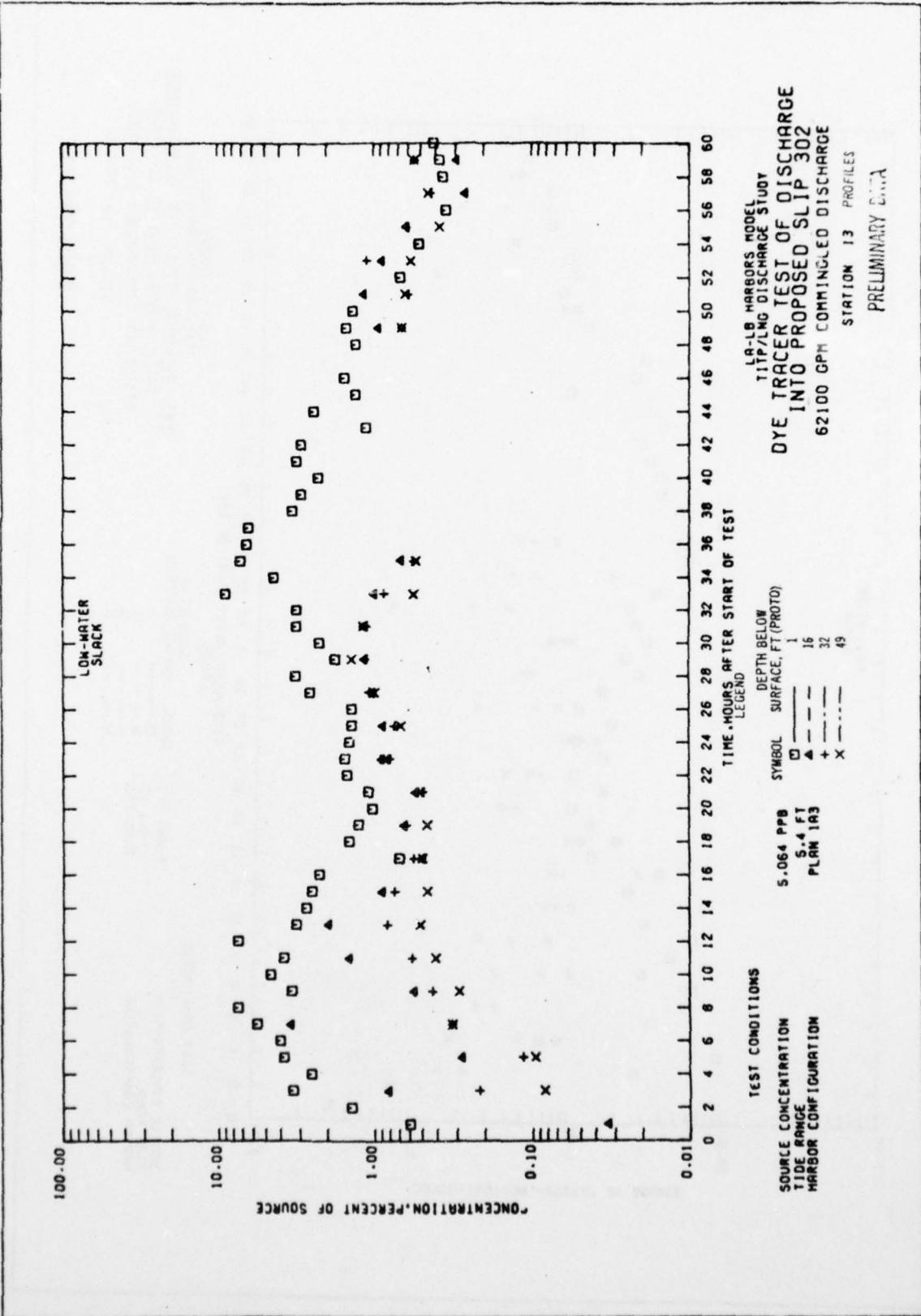


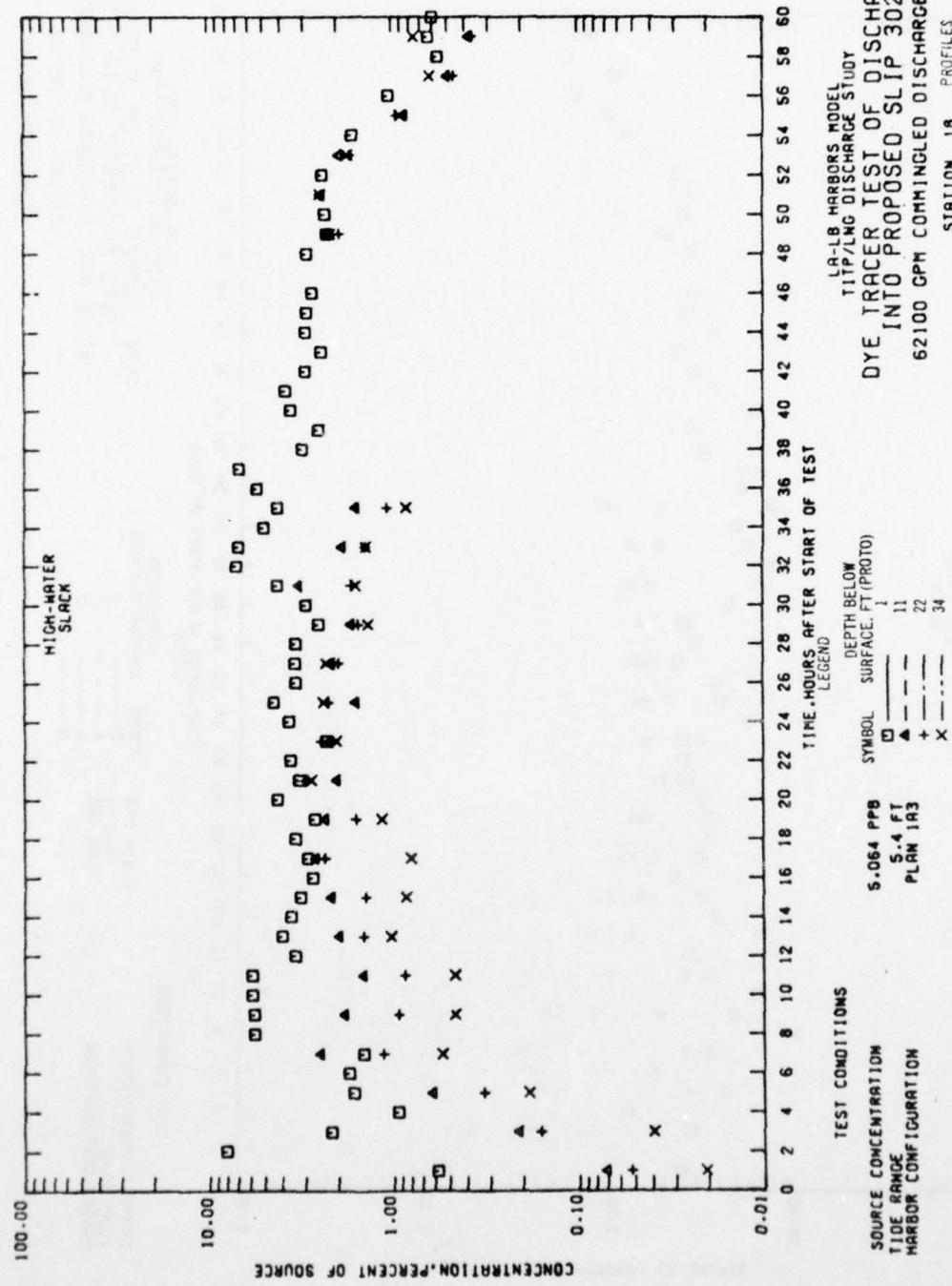


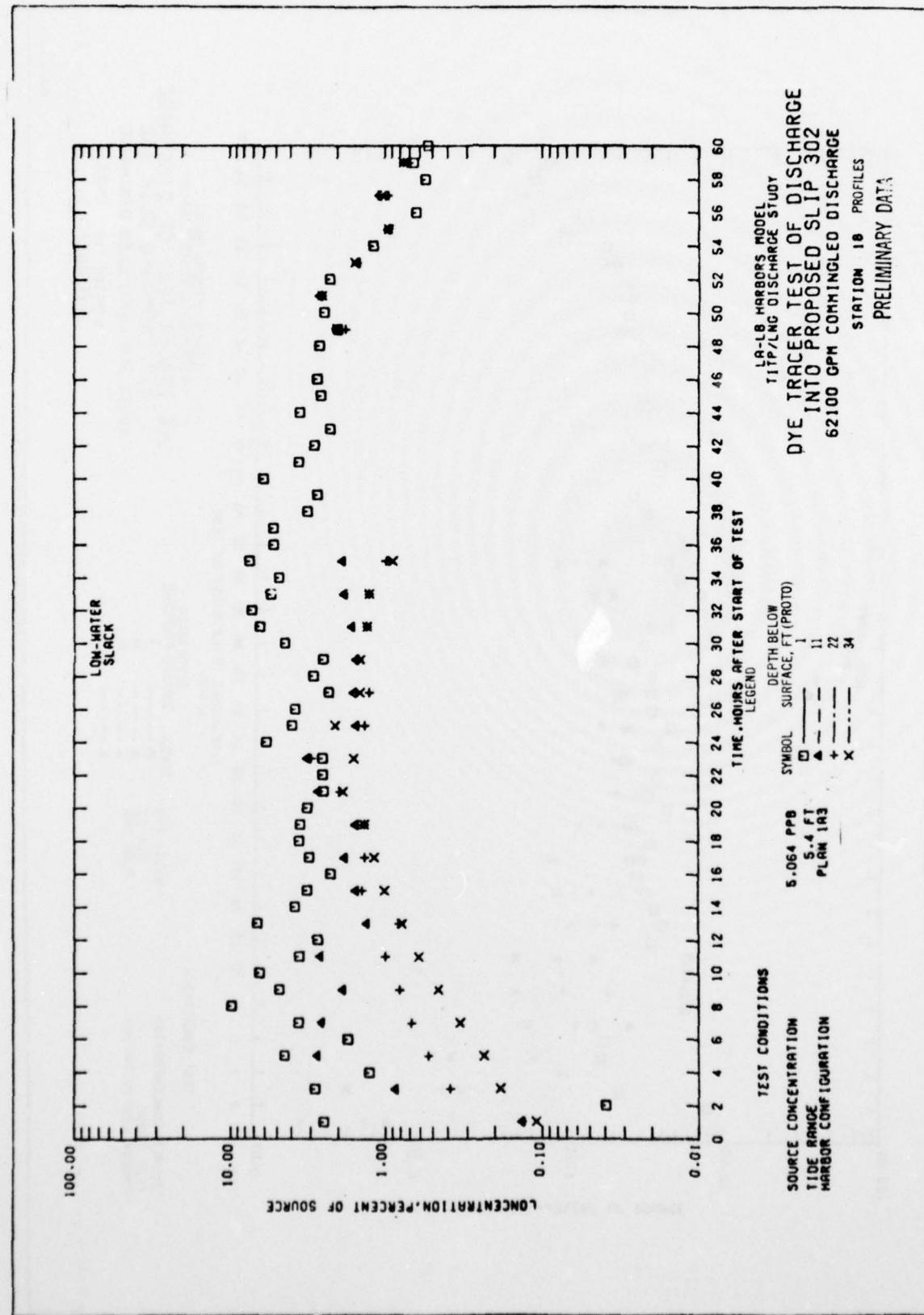












In accordance with letter from DAEN-RDC, DAEN-ASI dated 22 July 1977, Subject: Facsimile Catalog Cards for Laboratory Technical Publications, a facsimile catalog card in Library of Congress MARC format is reproduced below.

McAnally, William H

Model study of cool water discharge from proposed LNG facility, Los Angeles Harbor, California / by William H. McAnally, Jr. Vicksburg, Miss. : U. S. Waterways Experiment Station ; Springfield, Va. : available from National Technical Information Service, 1977.

3, [33] p., [145] leaves of plates : ill. ; 27 cm. (Miscellaneous paper - U. S. Army Engineer Waterways Experiment Station ; H-77-13)

Prepared for Port of Los Angeles, San Pedro, California.
Includes bibliographies.

1. Discharge (Water). 2. Los Angeles Harbor. 3. Model tests.
4. Stratification (Water). I. Port of Los Angeles.
- II. Series: United States. Waterways Experiment Station, Vicksburg, Miss. Miscellaneous paper ; H-77-13.

TA7.W34m no.H-77-13